Point Curvature: Large
Aspect Ratio: Small (≒1)

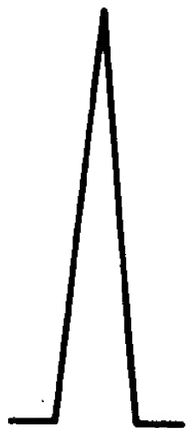
FIG. 1A PRIOR ART

Point Curvature: Little Small
Aspect Ratio: Small (≒4.5)

FIG. 1B PRIOR ART

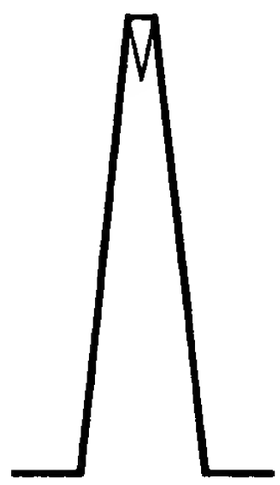
Point Curvature: Little Small
Aspect Ratio: Small (≒1)

FIG. 1C PRIOR ART



Point Curvature: Small (Several nm)
Aspect Ratio: Large (≒10)

FIG. 1D PRESENT INVENTION



Point Curvature: Small (Several nm)
Aspect Ratio: Large (≒10)

FIG. 1E PRESENT INVENTION

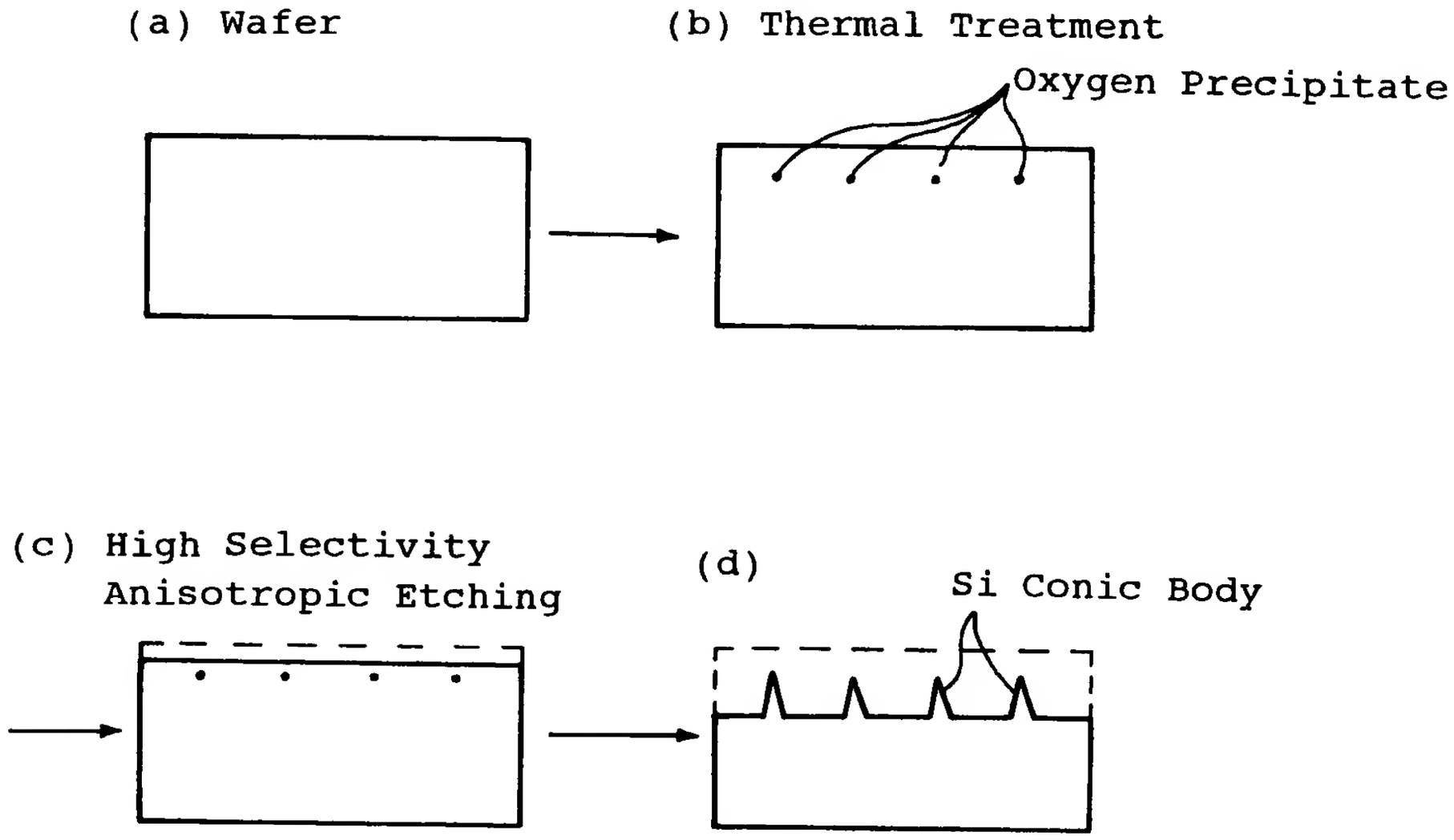
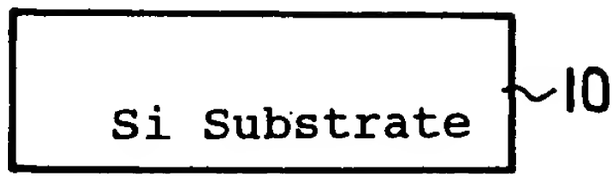

(a) Wafer
(b) Thermal Treatment
Oxygen Precipitate
(c) High Selectivity
Anisotropic Etching
(d)
Si Conic Body

FIG. 2

FIG. 3A



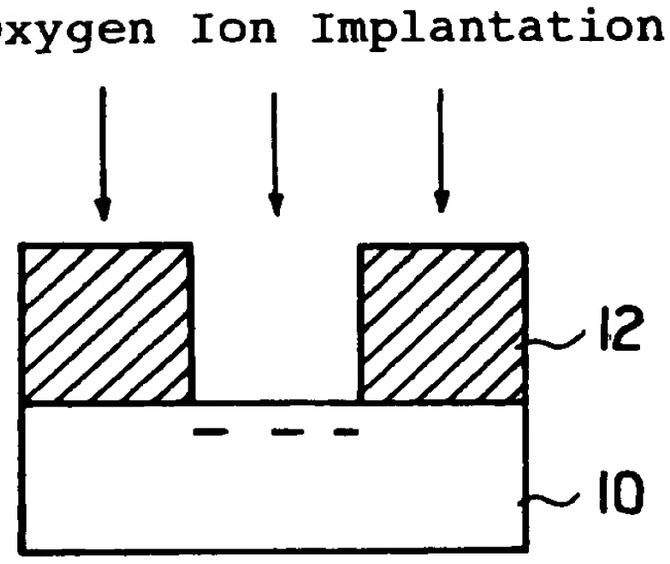


FIG. 3B

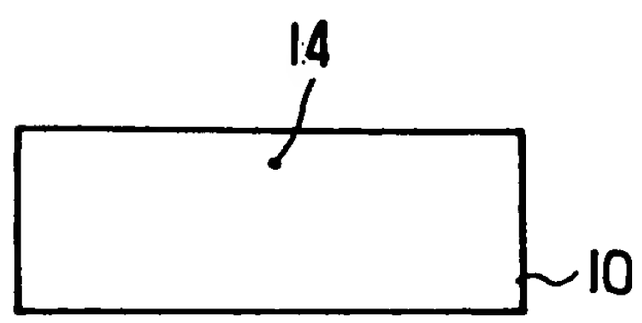


FIG. 3C

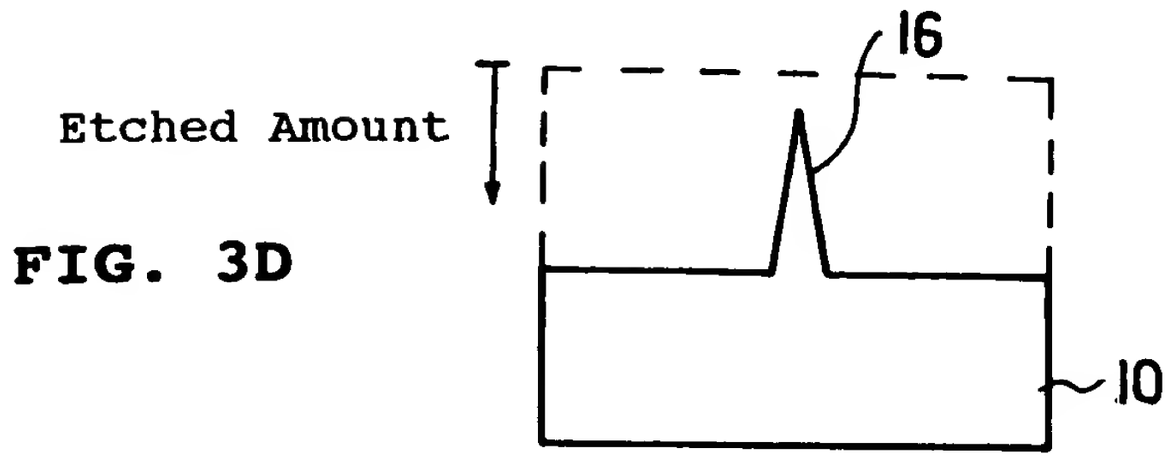
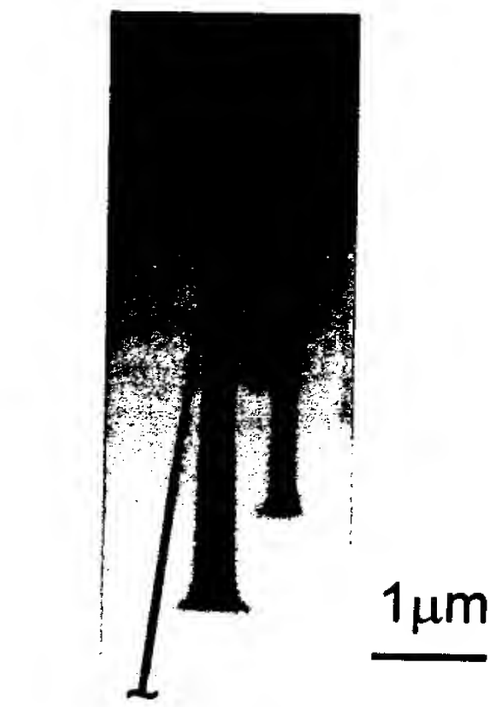


FIG. 3D



TO FIG.4B

FIG.4A

FROM FIG.4A

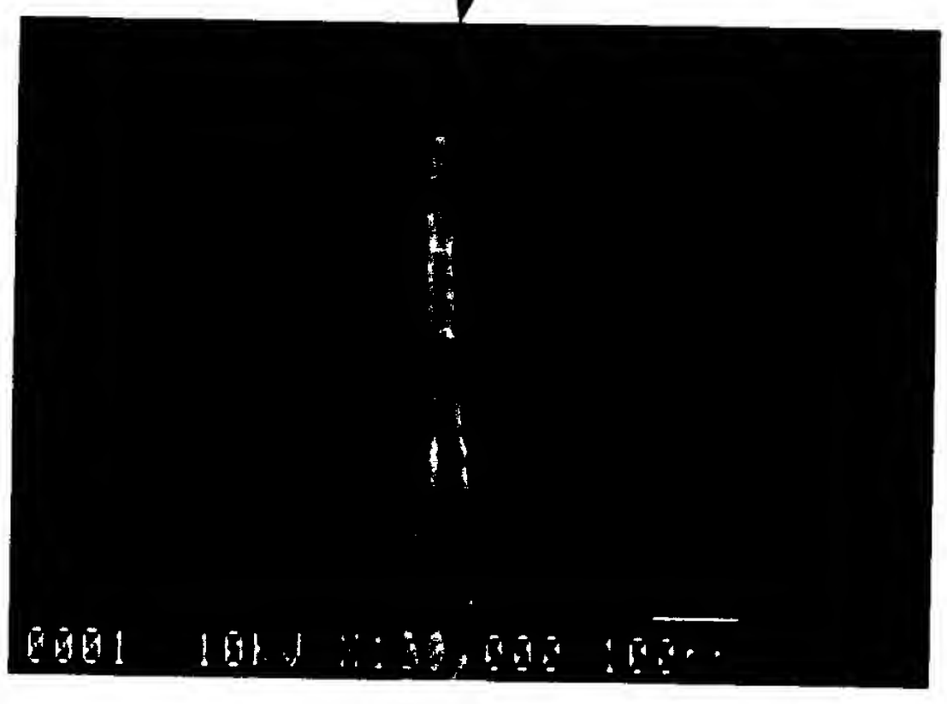


FIG.4B

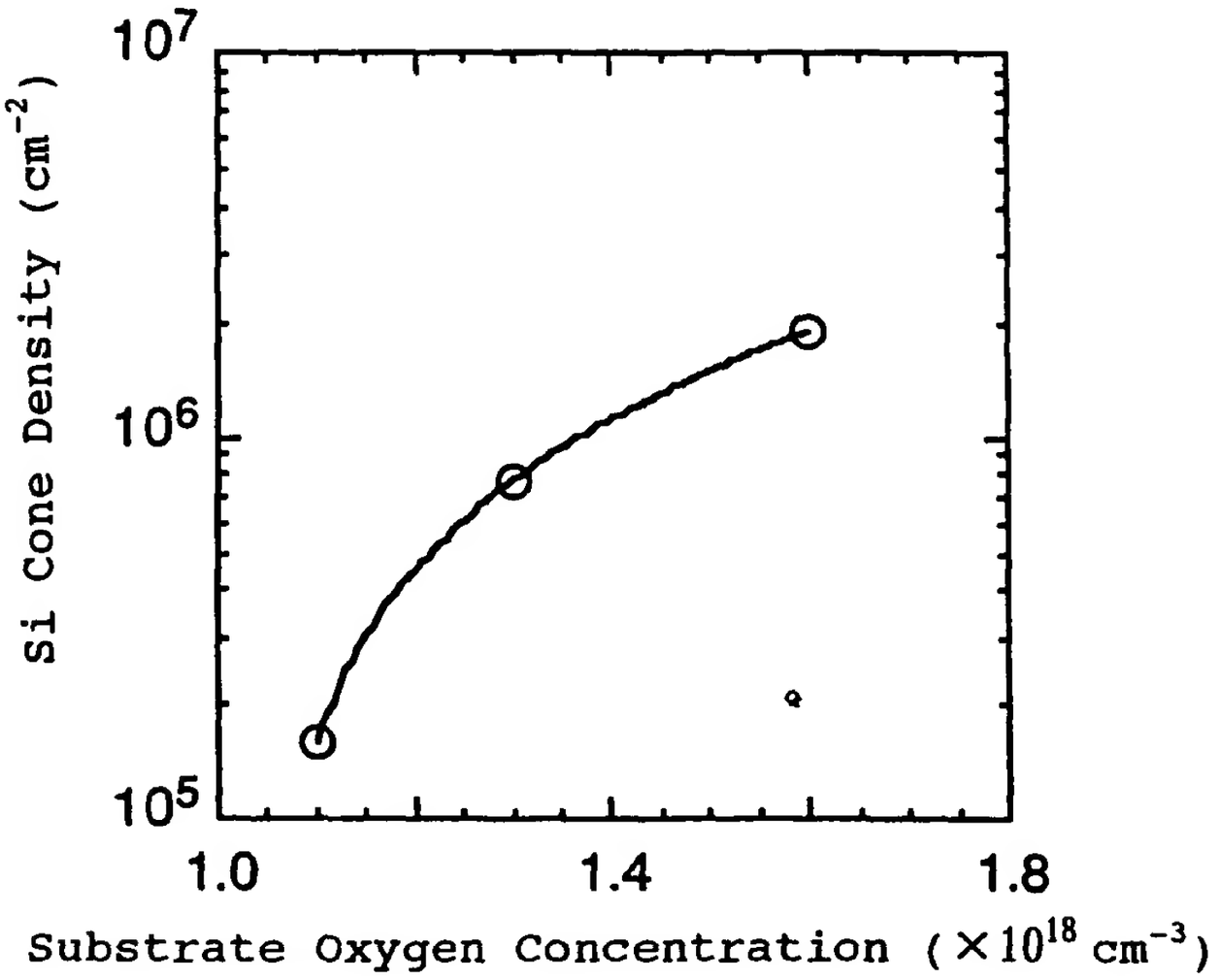

Si Cone Density (cm^{-2})
10^7
10^6
10^5
1.0
1.4
1.8
Substrate Oxygen Concentration ($\times 10^{18}\ cm^{-3}$)

FIG. 5

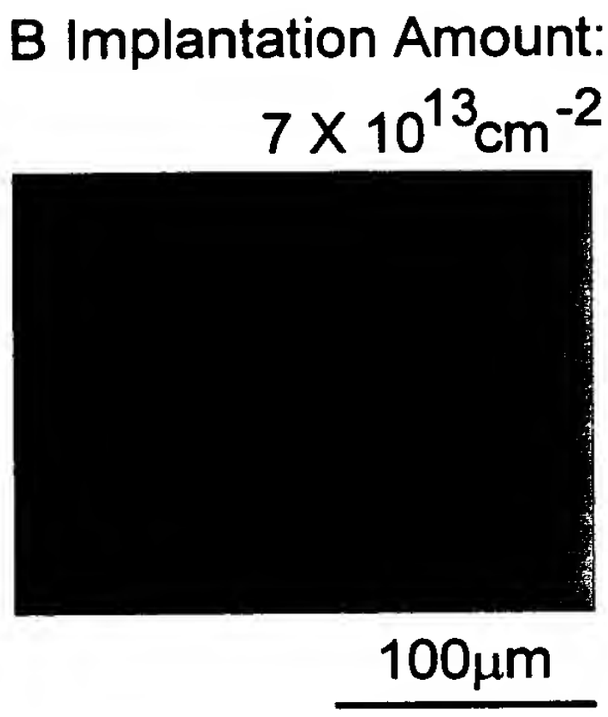

B Implantation Amount:
7 X 10^13cm^-2
100μm

FIG.6A

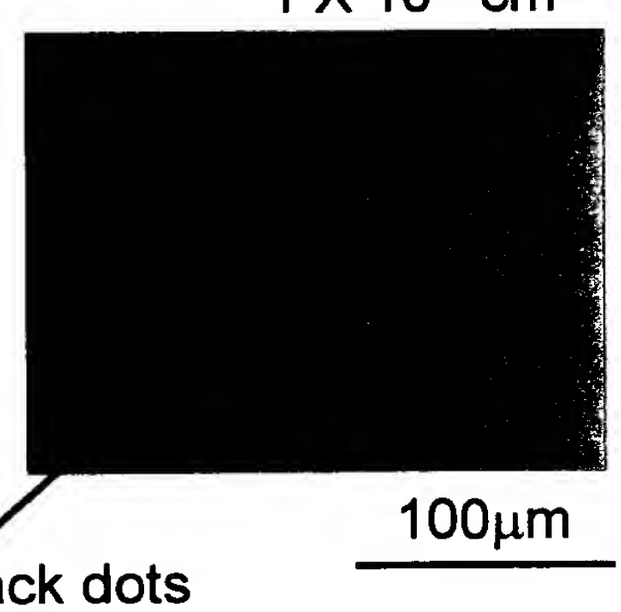

B Implantation Amount:
1 X 10^14cm^-2
100μm
Black dots
are silicon needle conic bodies.

FIG.6B

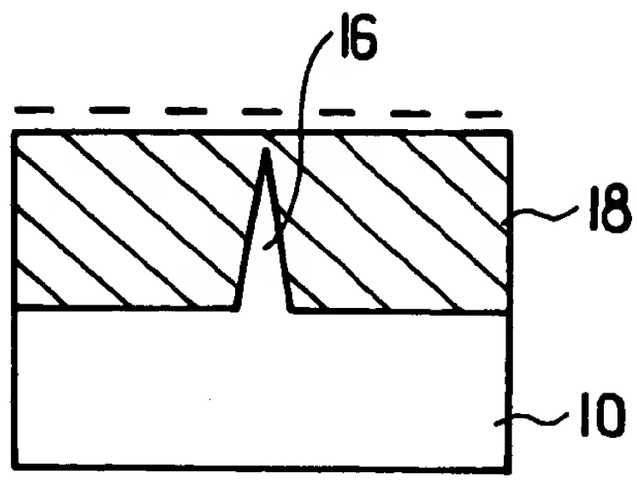


FIG. 7A

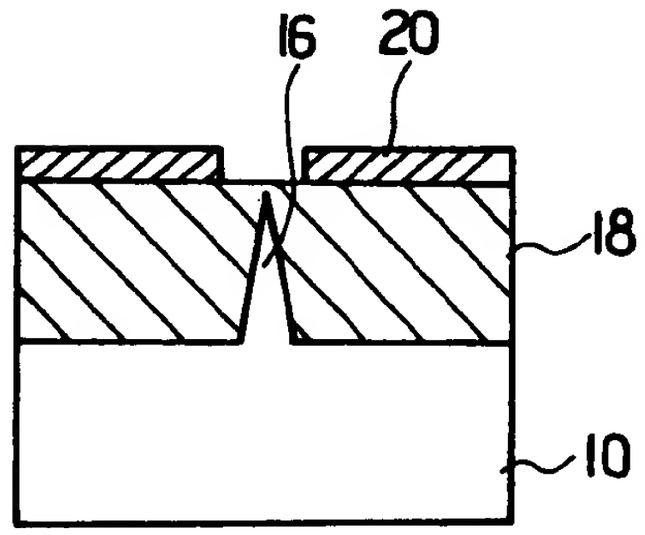


FIG. 7B

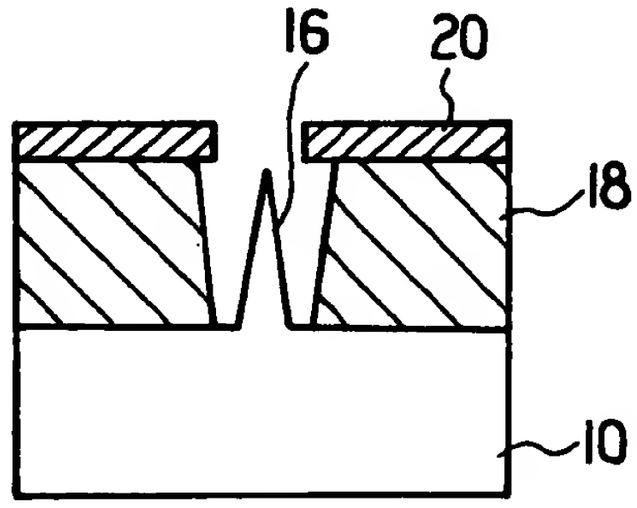


FIG. 7C

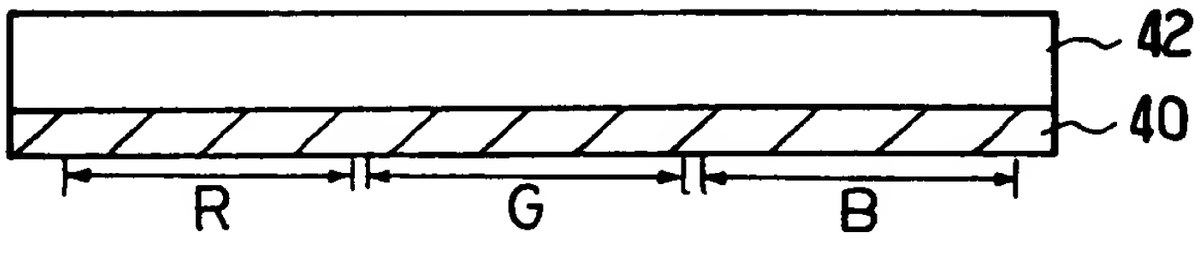


FIG. 8A

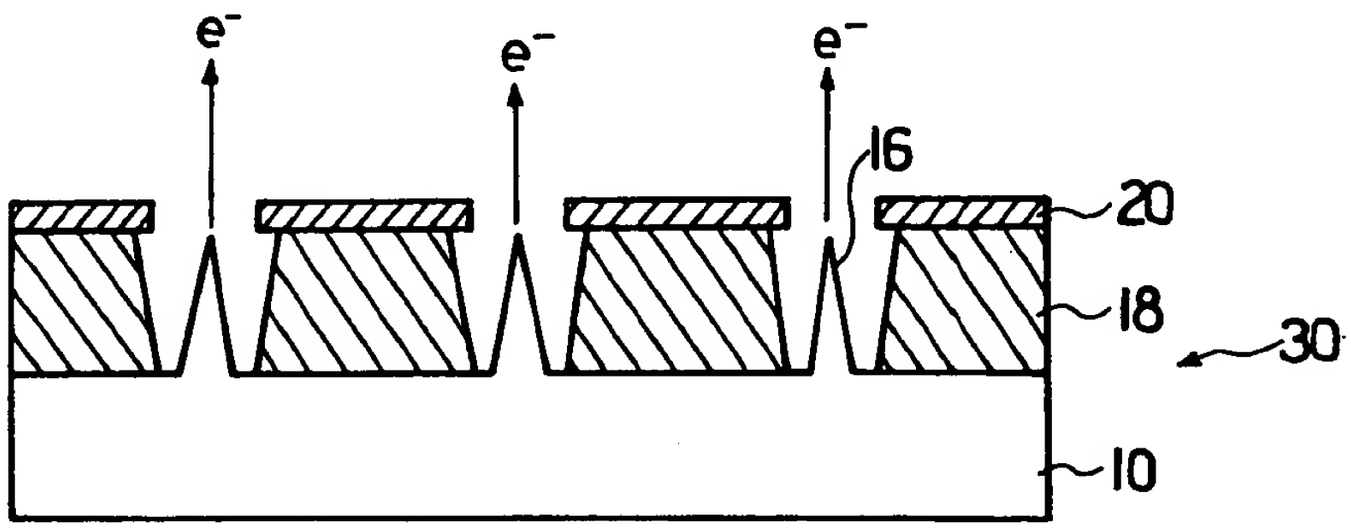
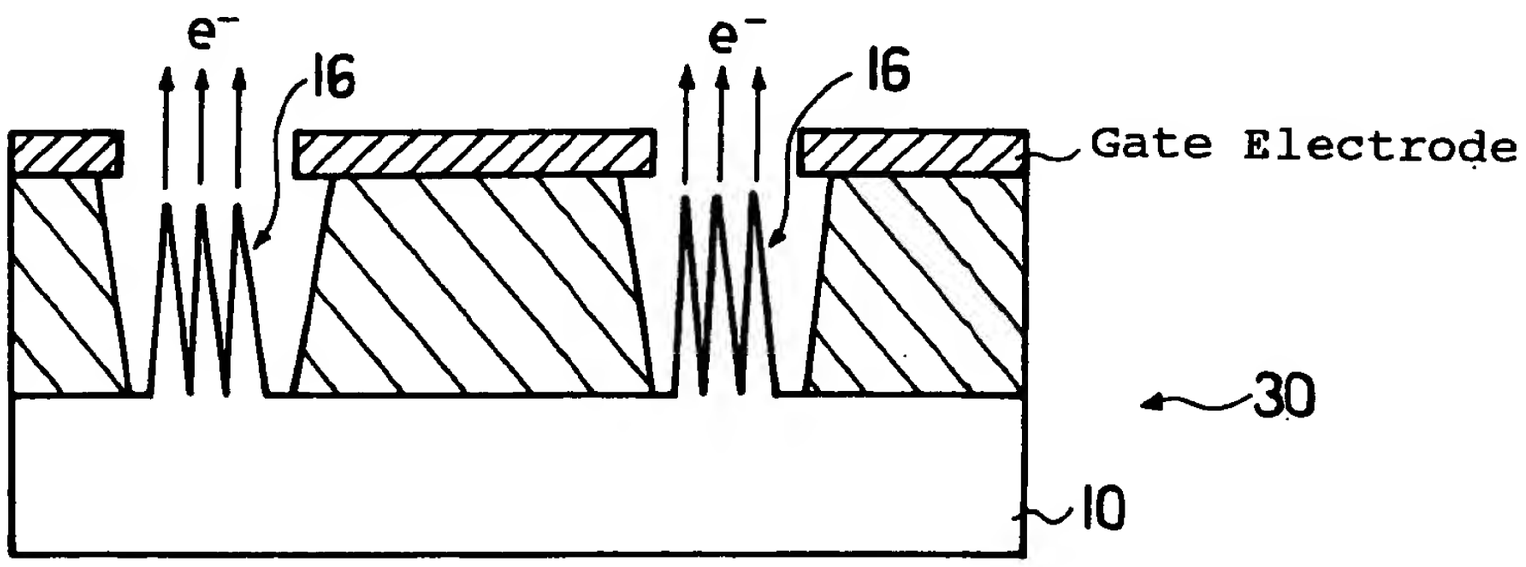


FIG. 8B



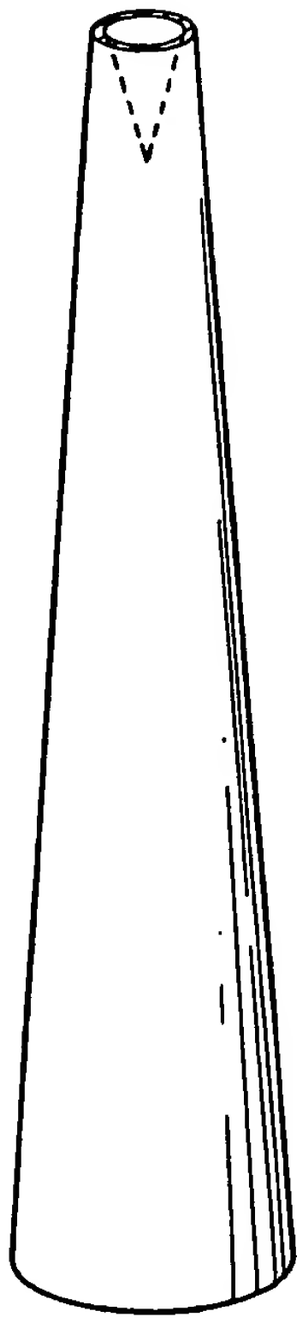


FIG. 9A

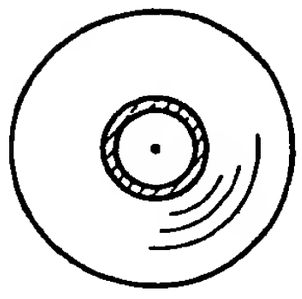


FIG. 9B

FIG. 10A

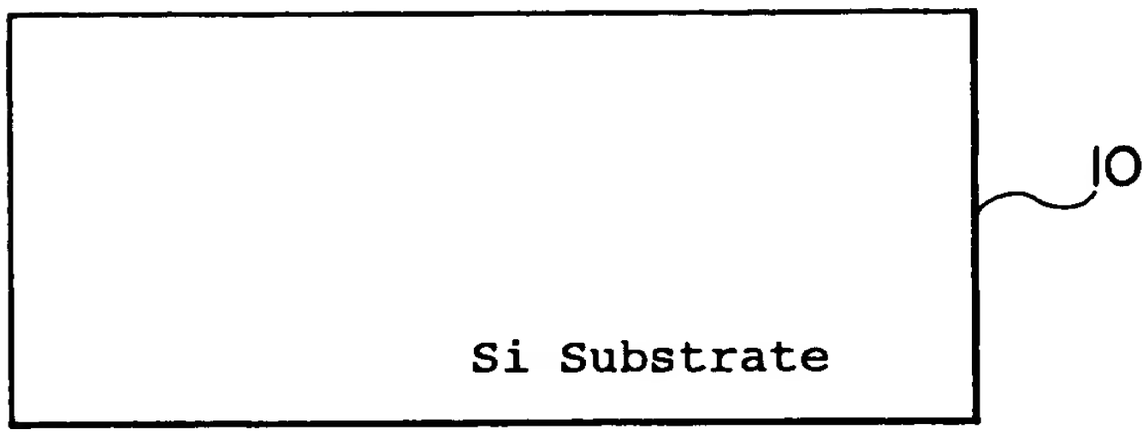


FIG. 10B

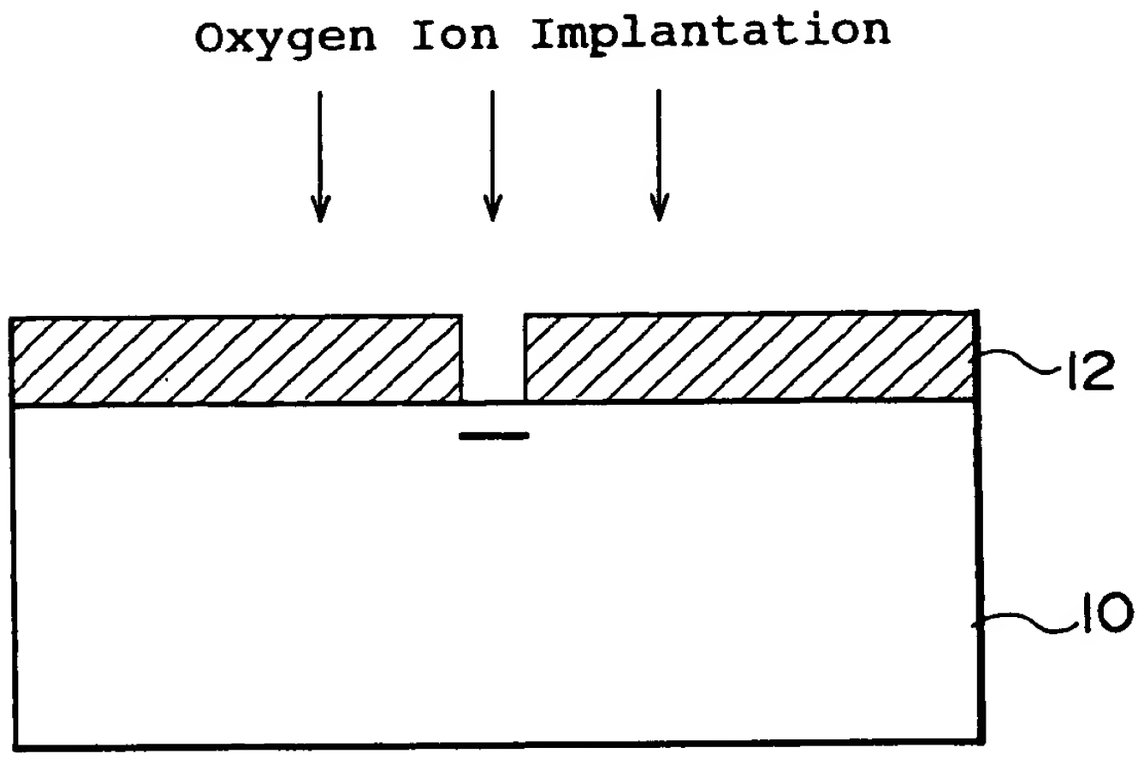
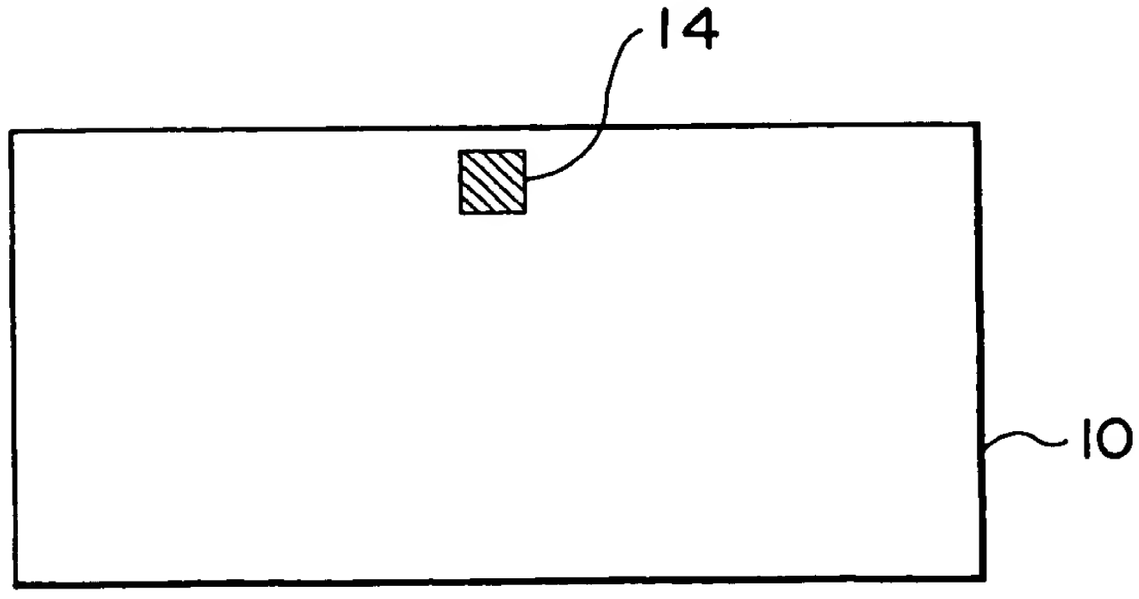


FIG. 10C



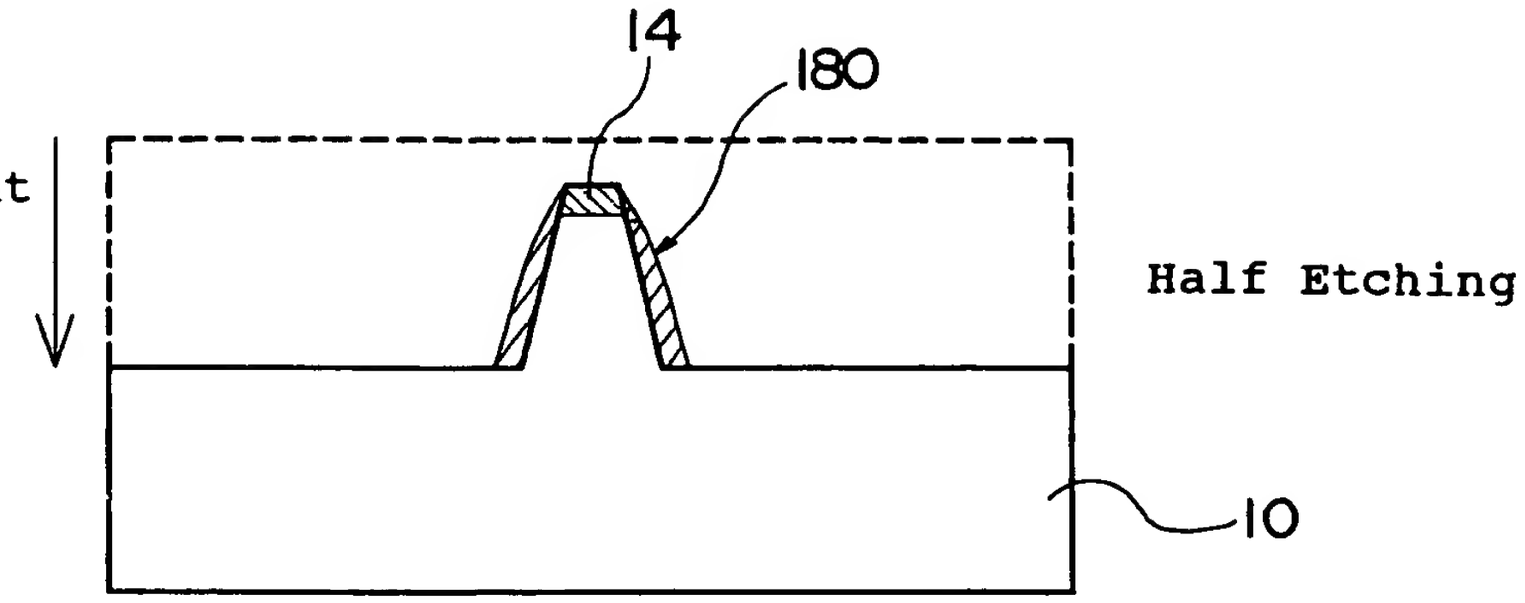


FIG. 10D

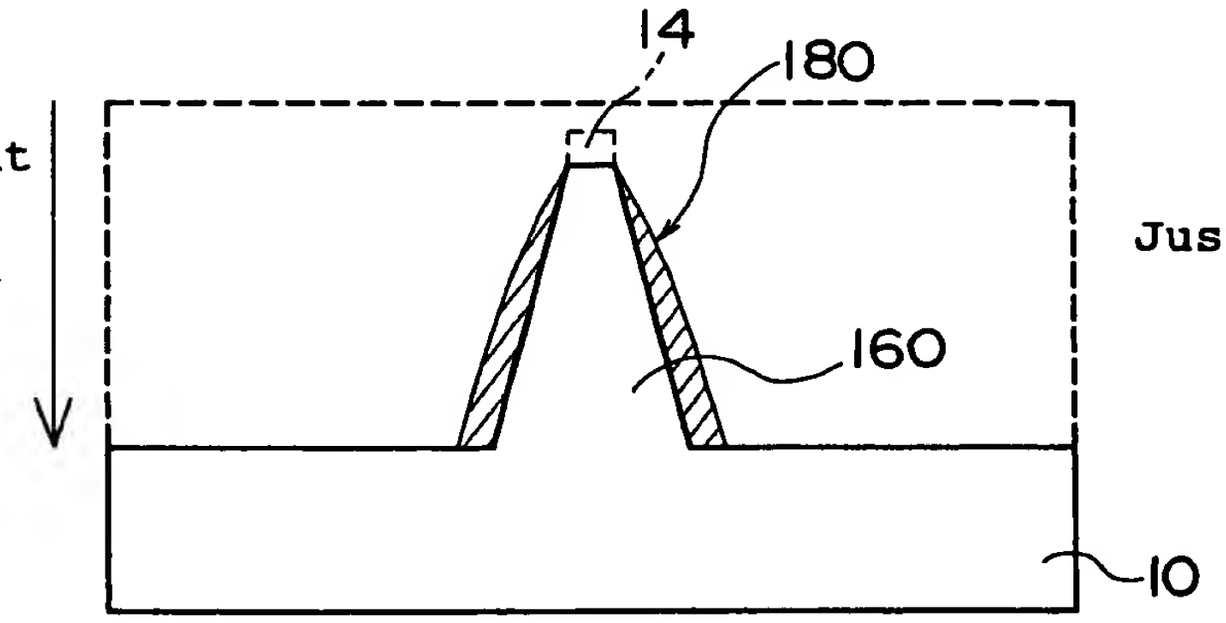


FIG. 10E

200

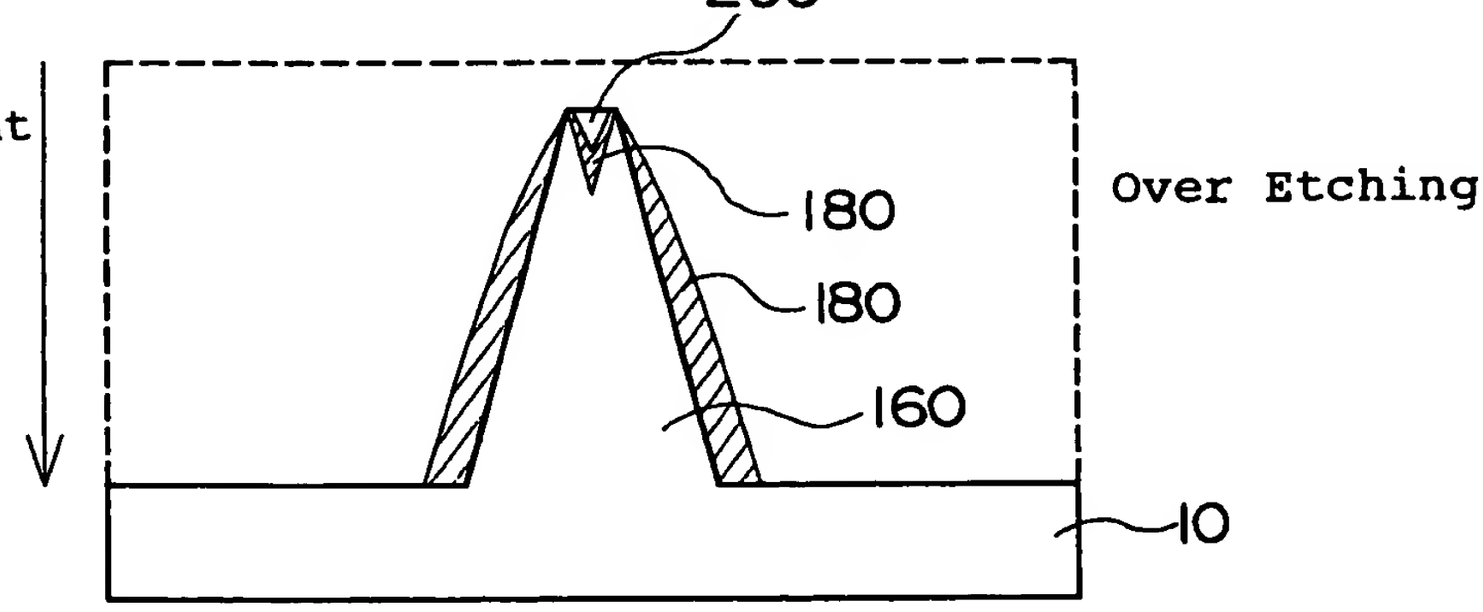


FIG. 10F

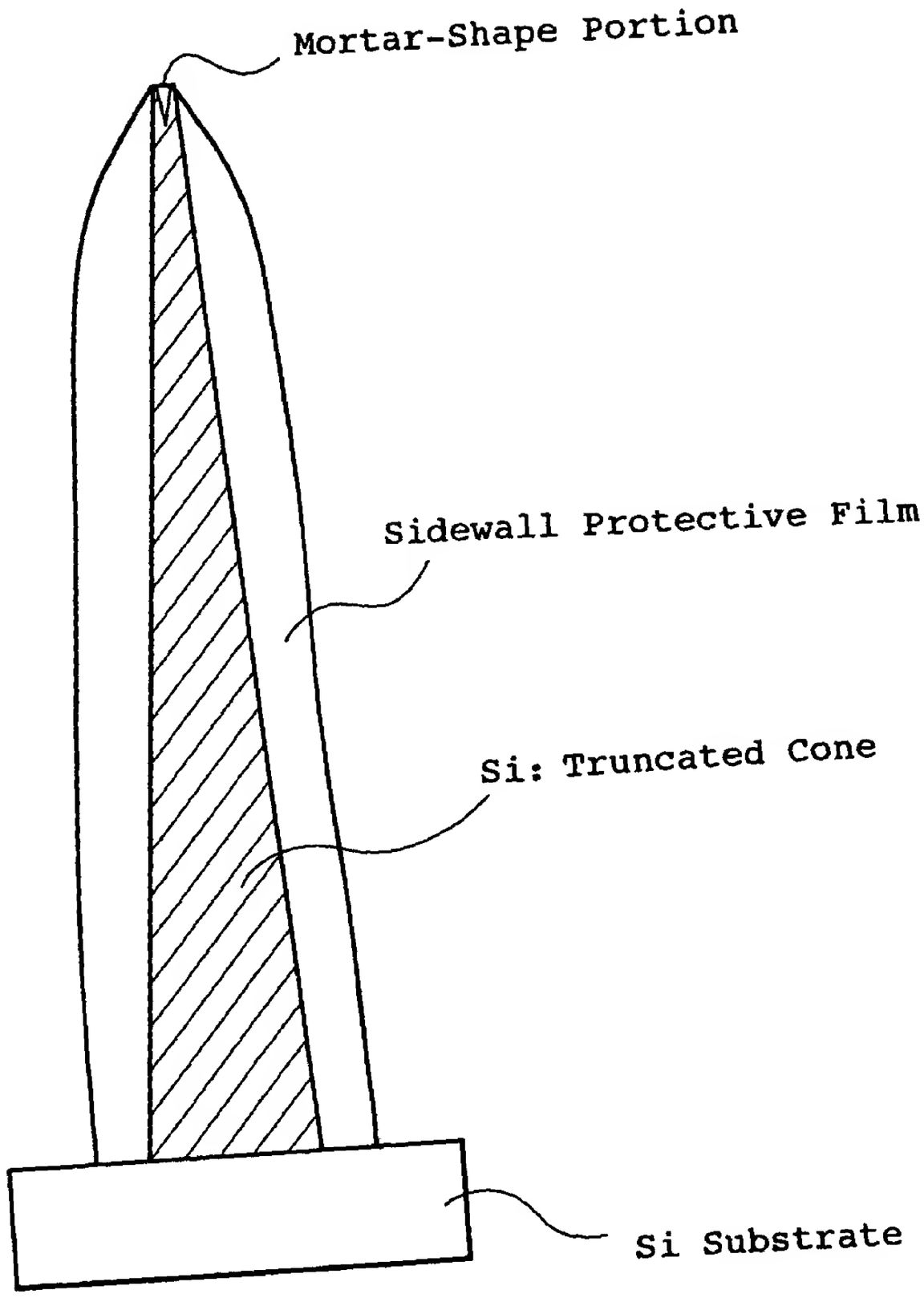

Mortar-Shape Portion
Sidewall Protective Film
Si: Truncated Cone
Si Substrate

FIG. 11

FIG. 12A

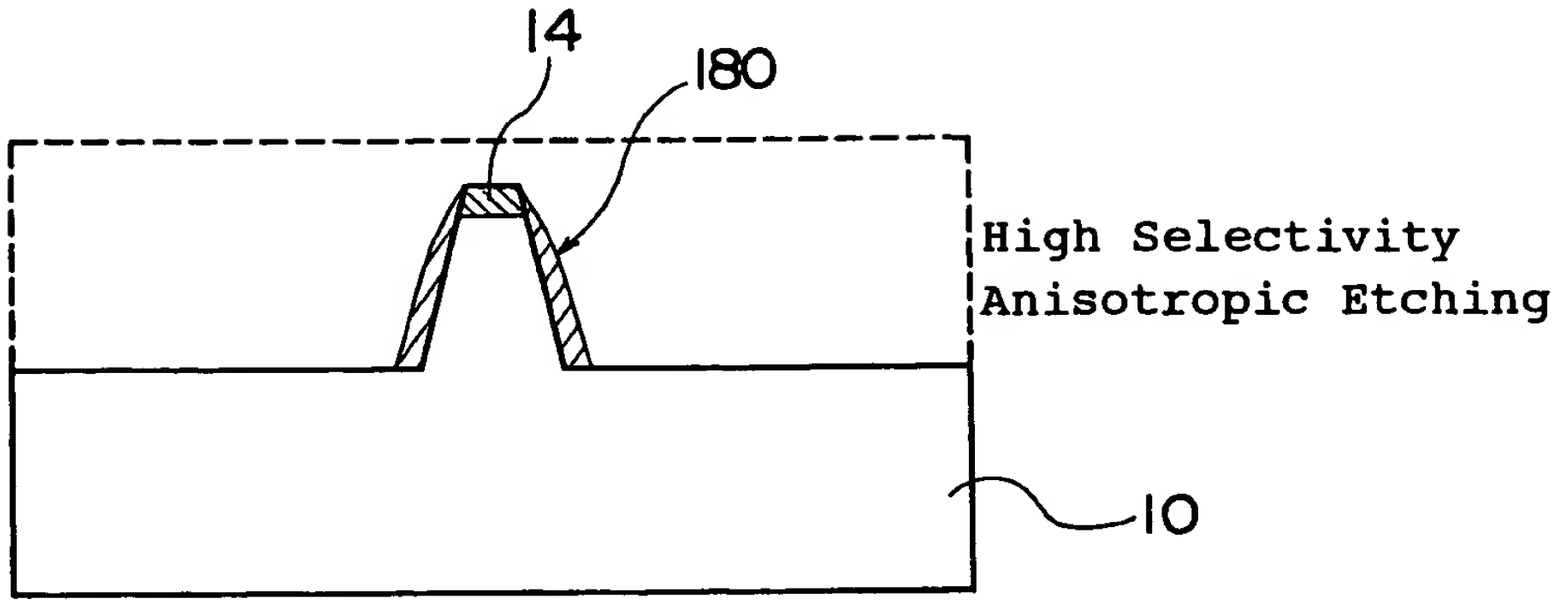
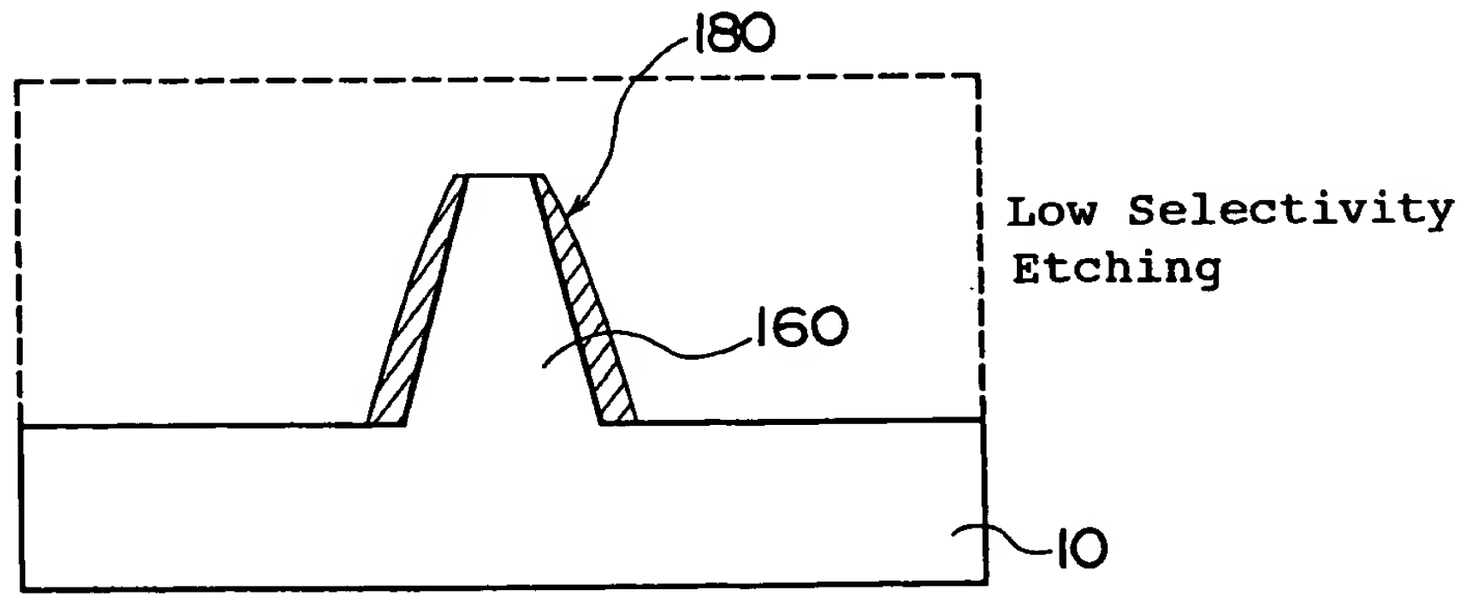
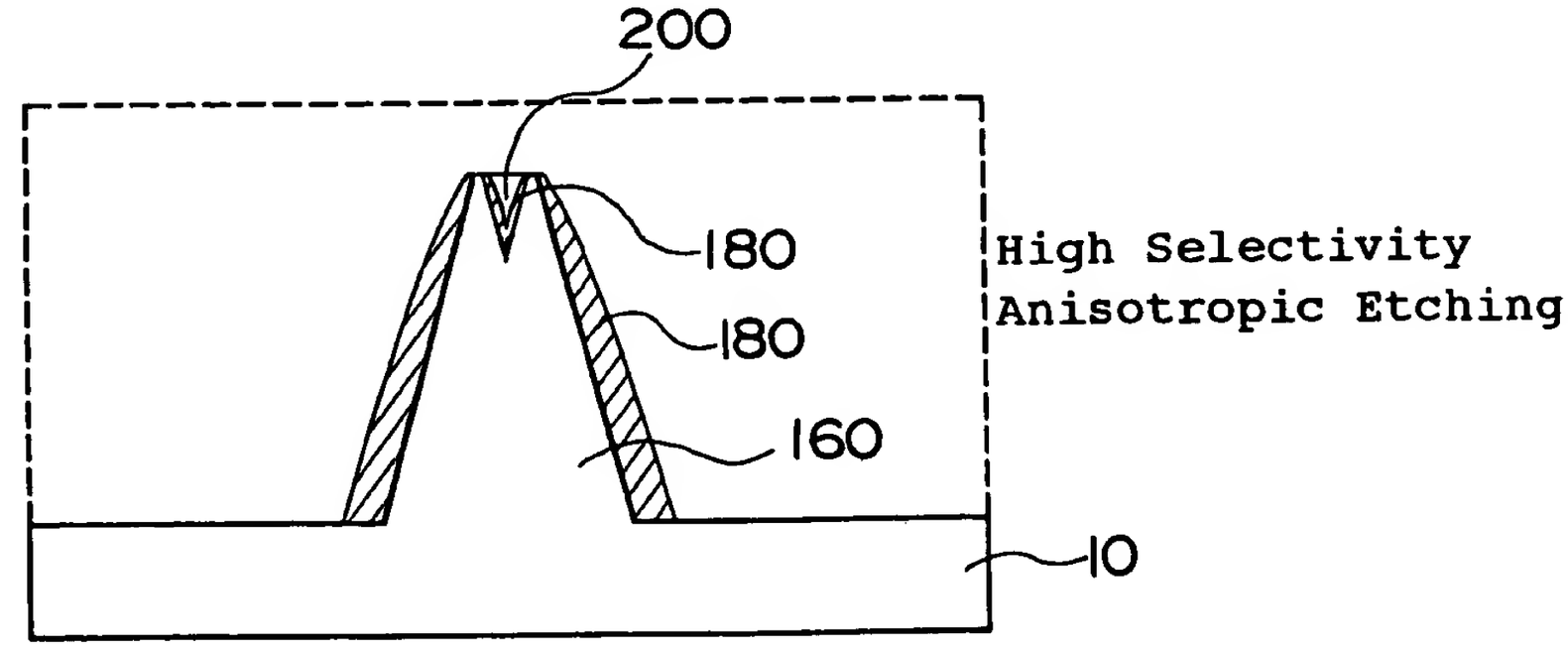


FIG. 12B



200

FIG. 12C



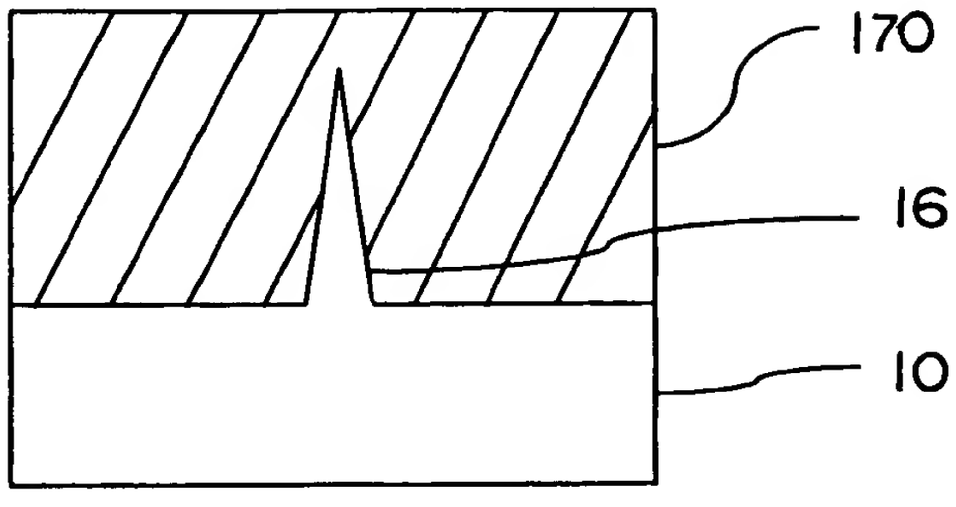


FIG. 13A

CMP or Etch Back

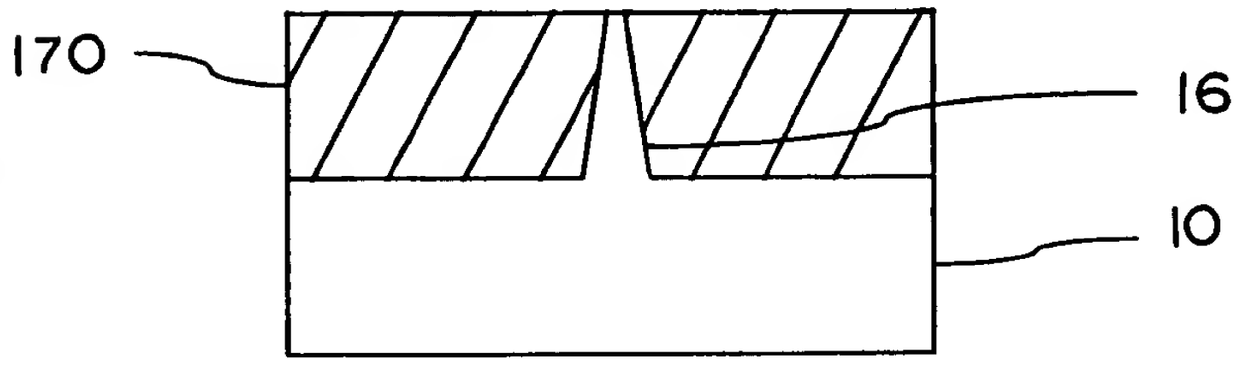


FIG. 13B

High Selectivity
Anisotropic Etching

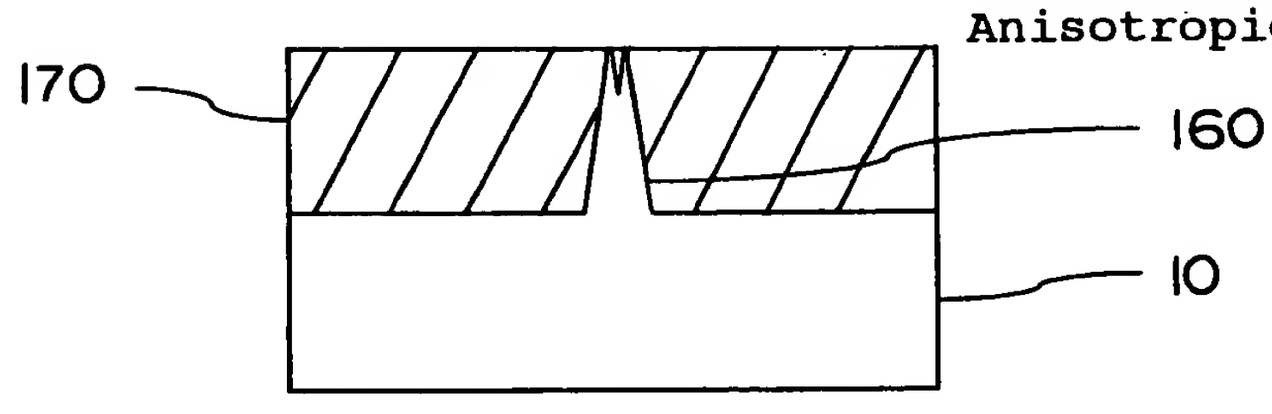


FIG. 13C

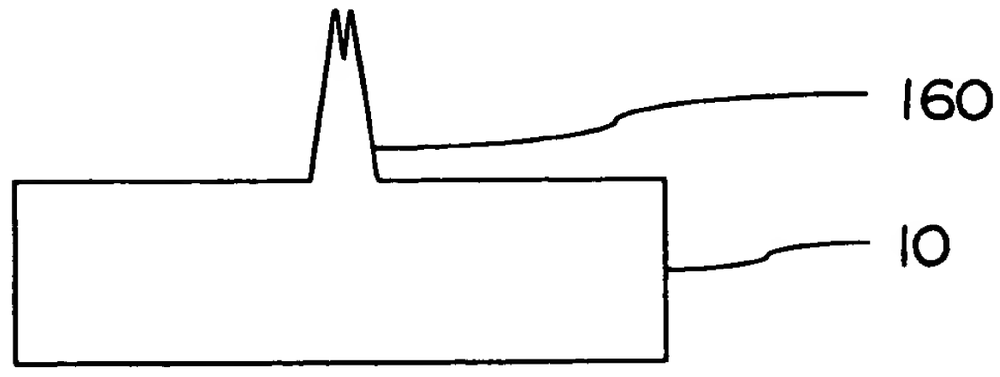


FIG. 13D

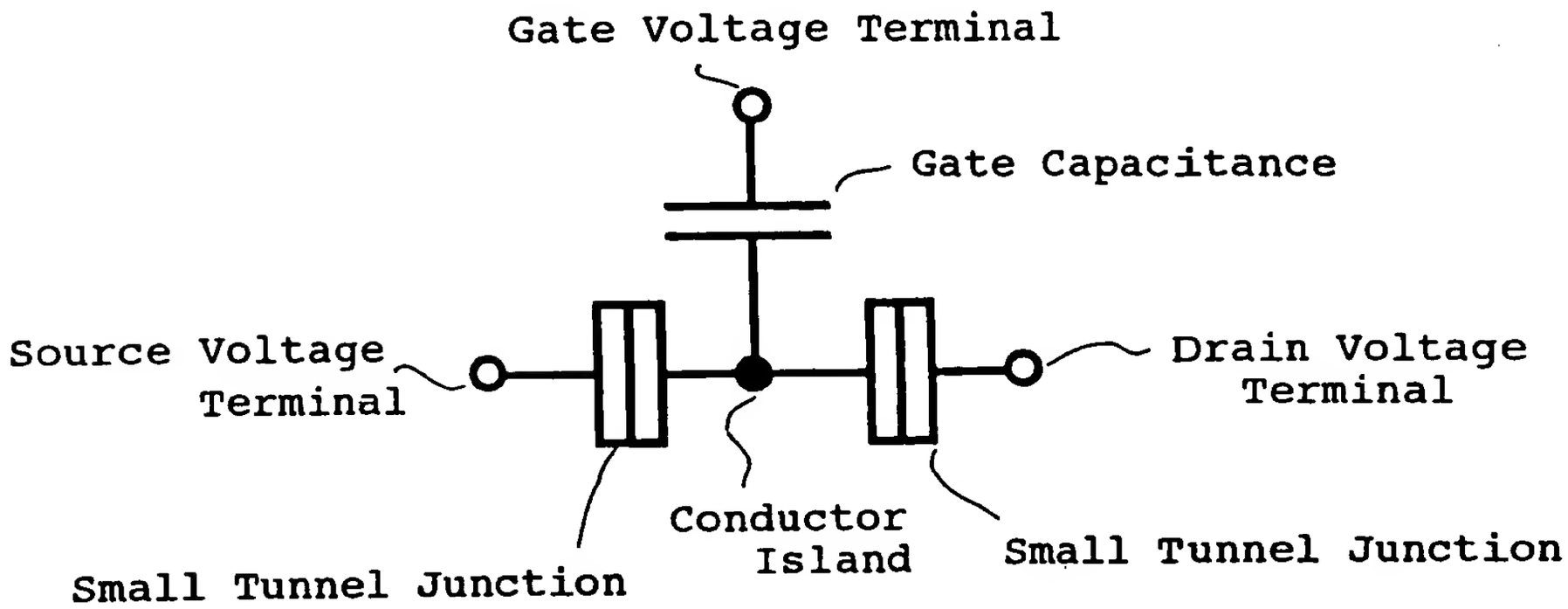


FIG. 14A PRIOR ART

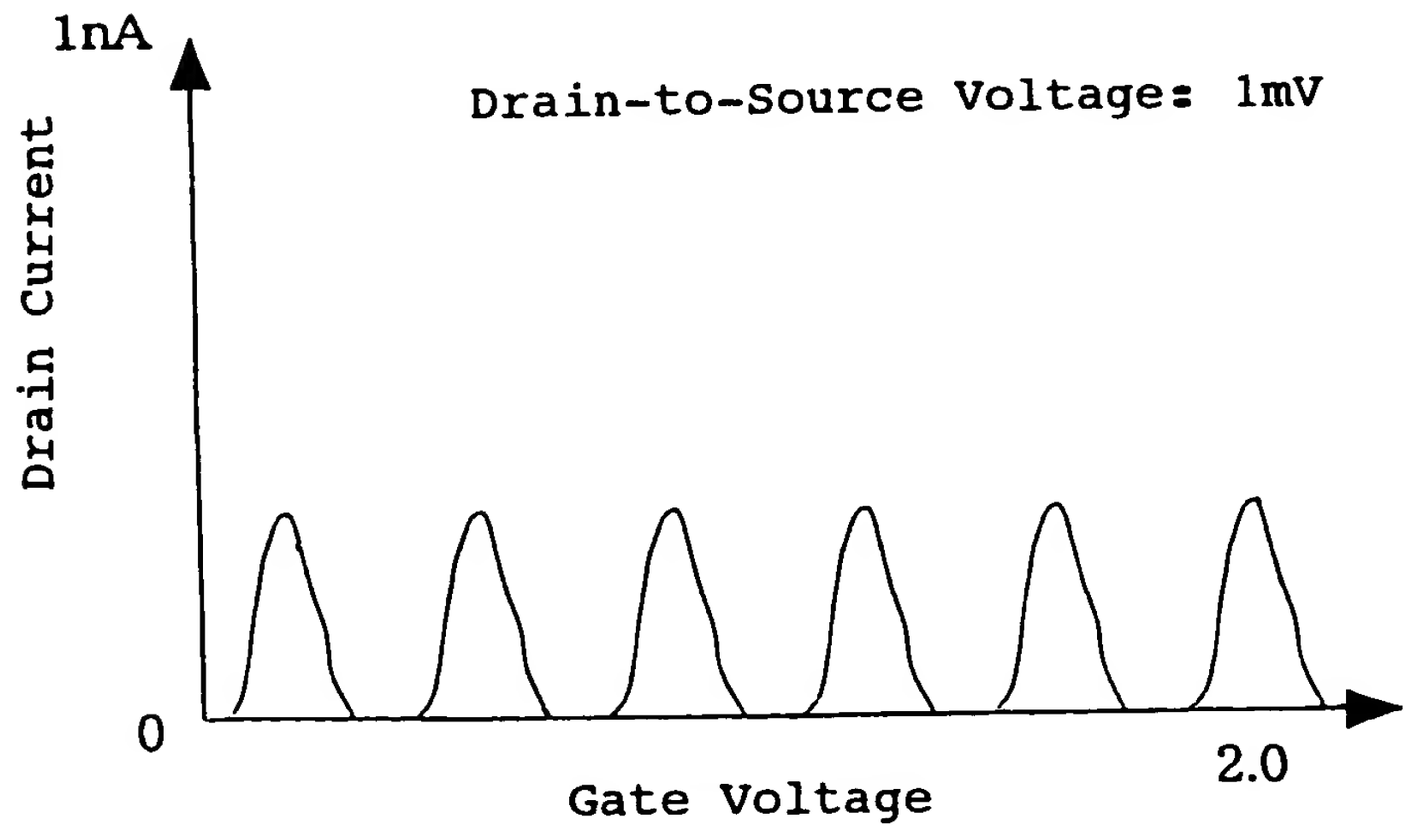


FIG. 14B PRIOR ART

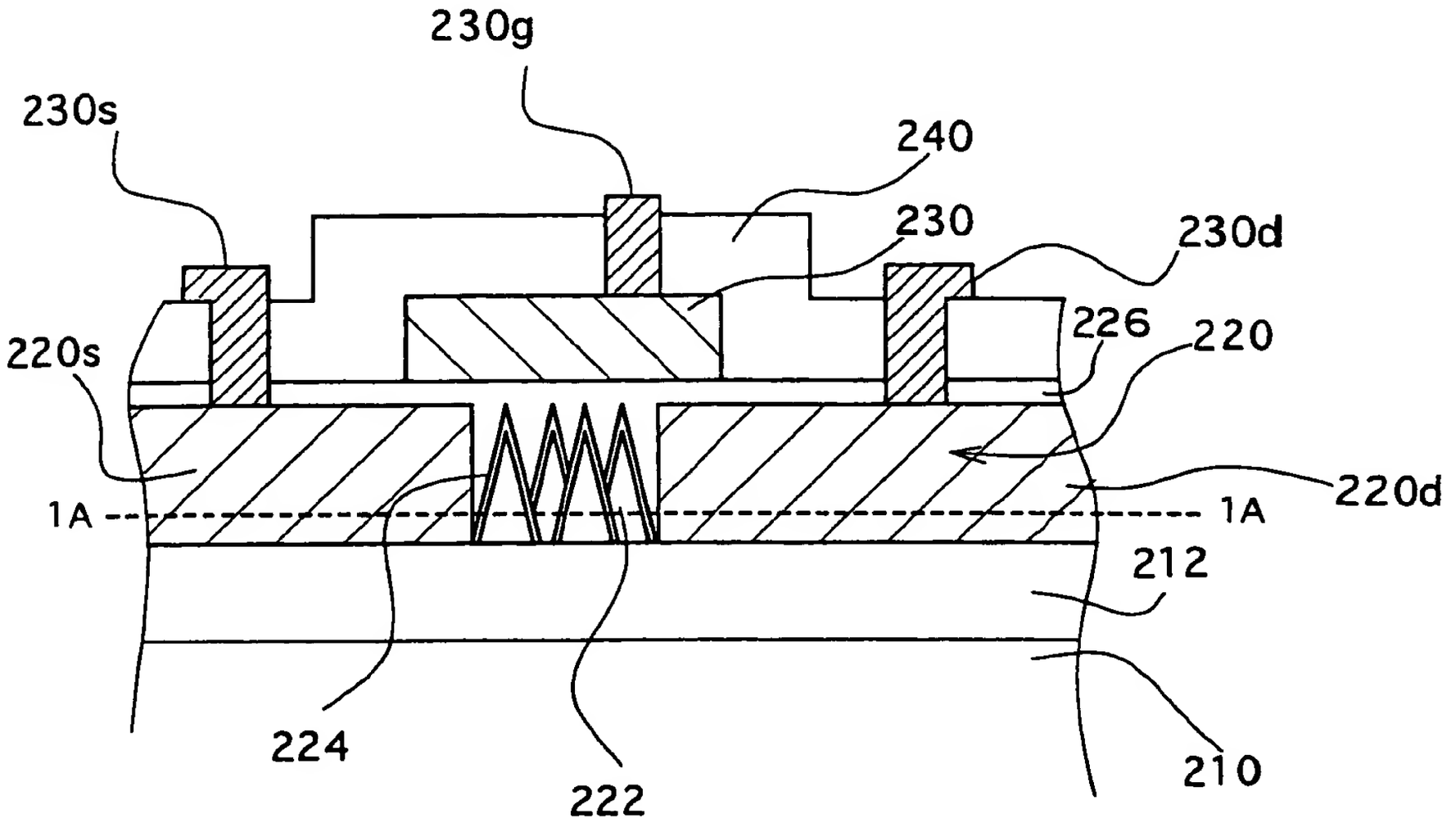


FIG. 15A

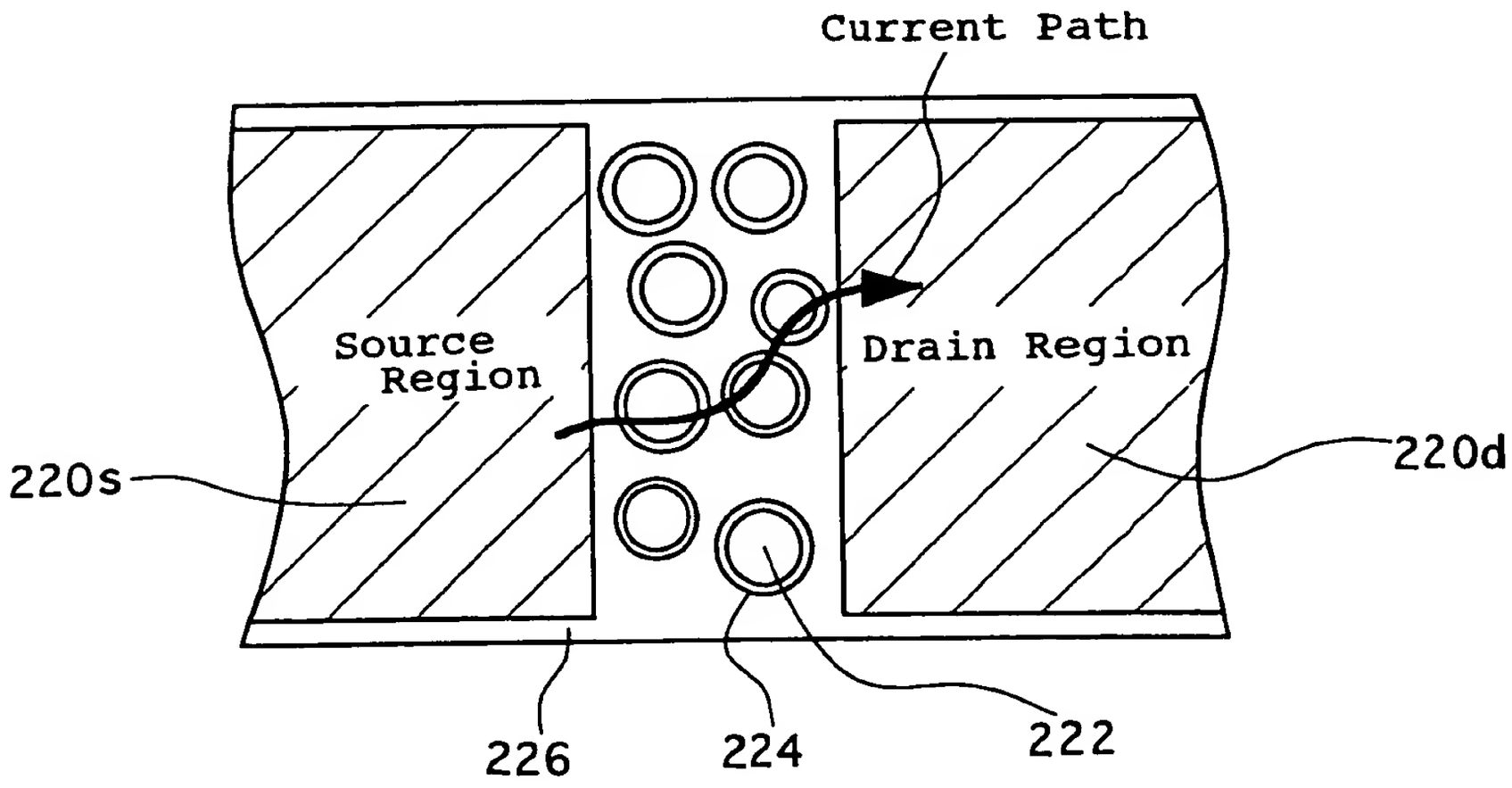


FIG. 15B

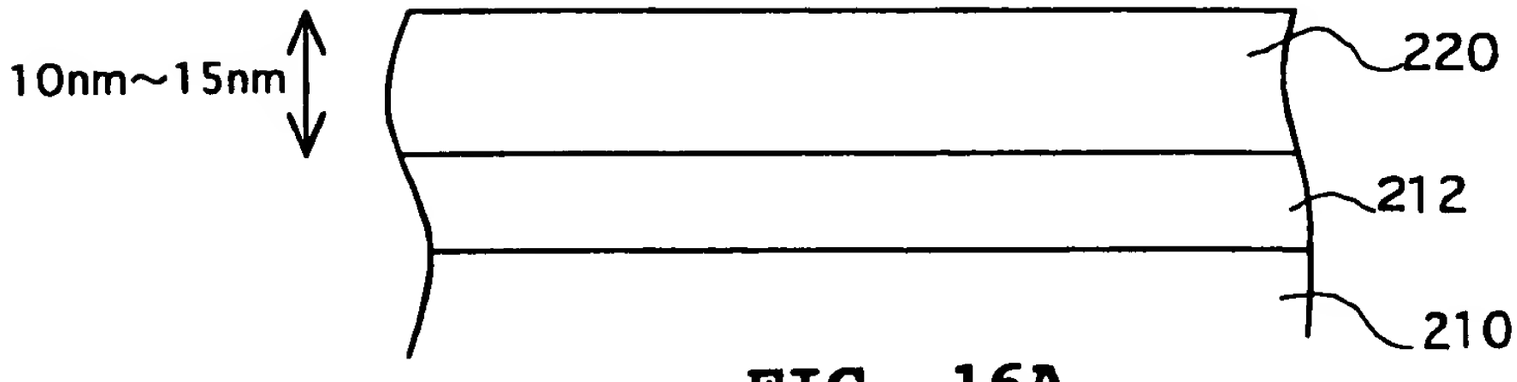


FIG. 16A

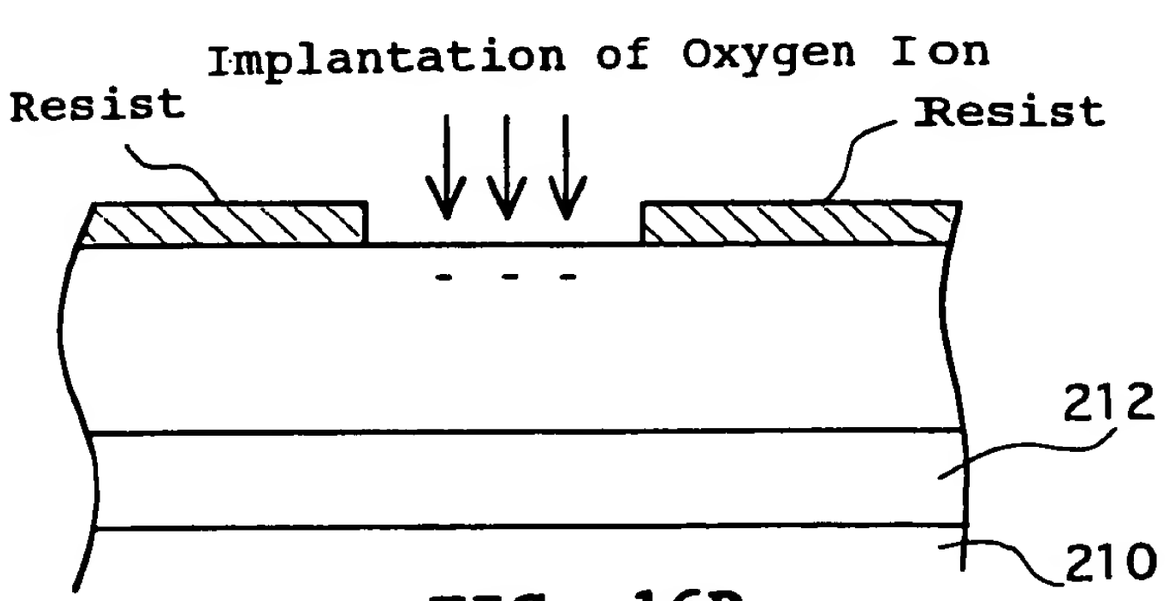


FIG. 16B

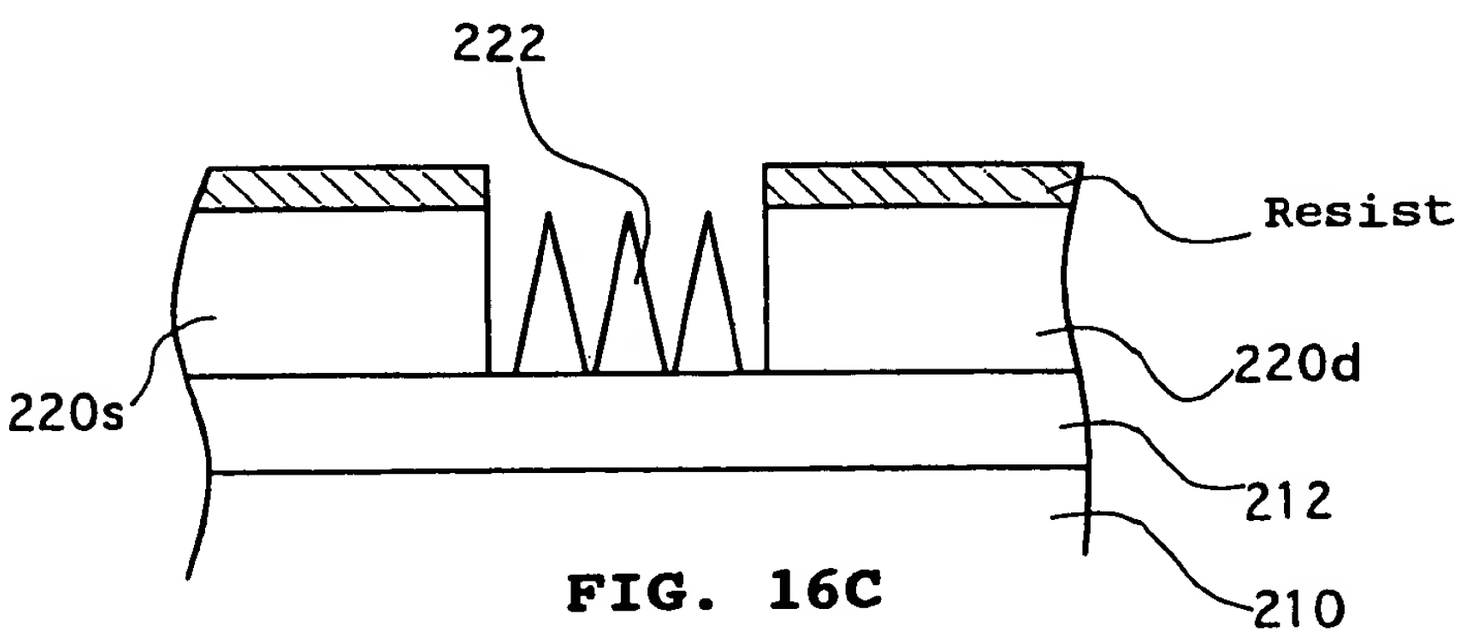


FIG. 16C

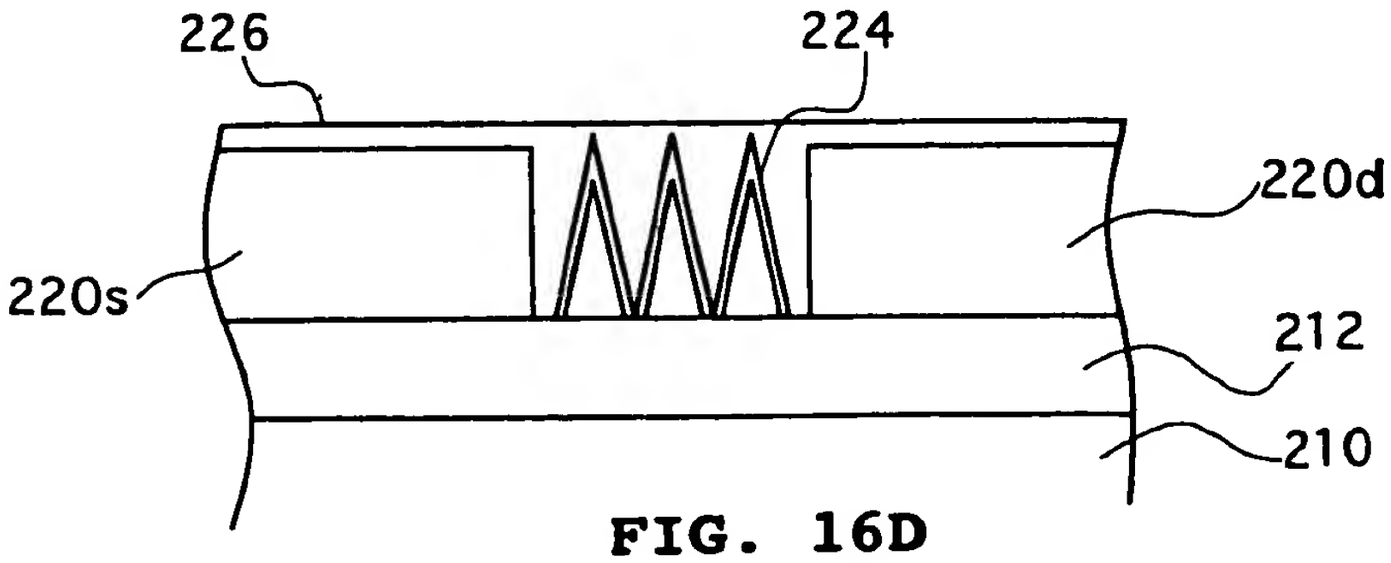


FIG. 16D

FIG. 16E

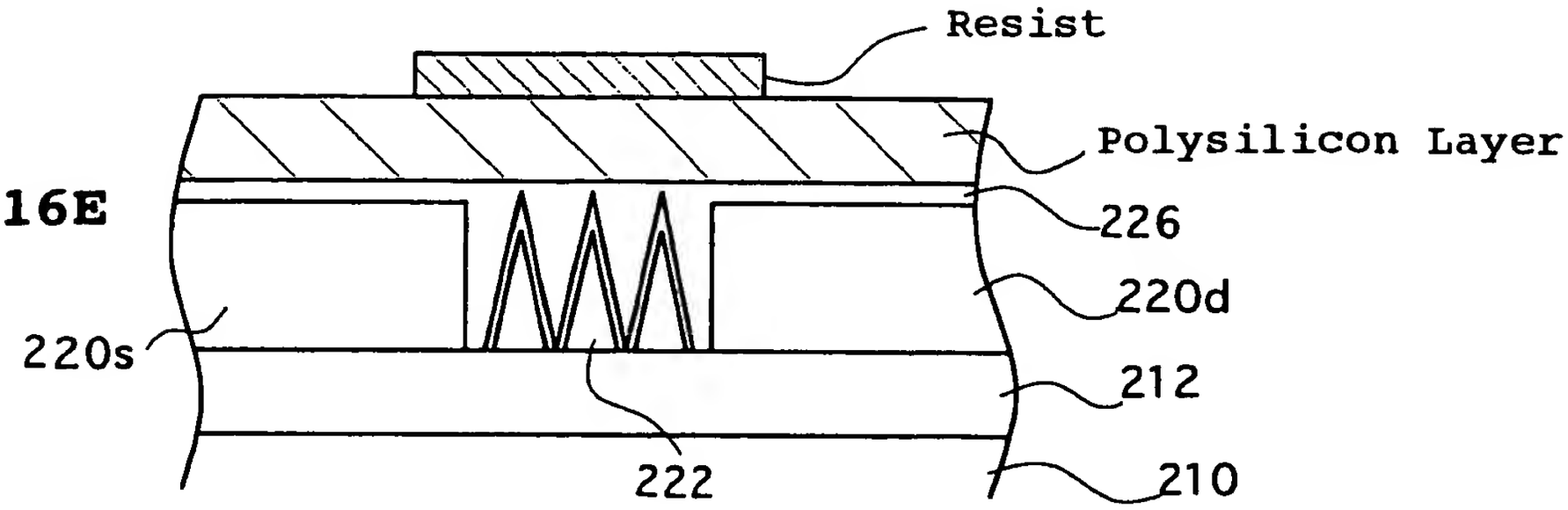


FIG. 16F

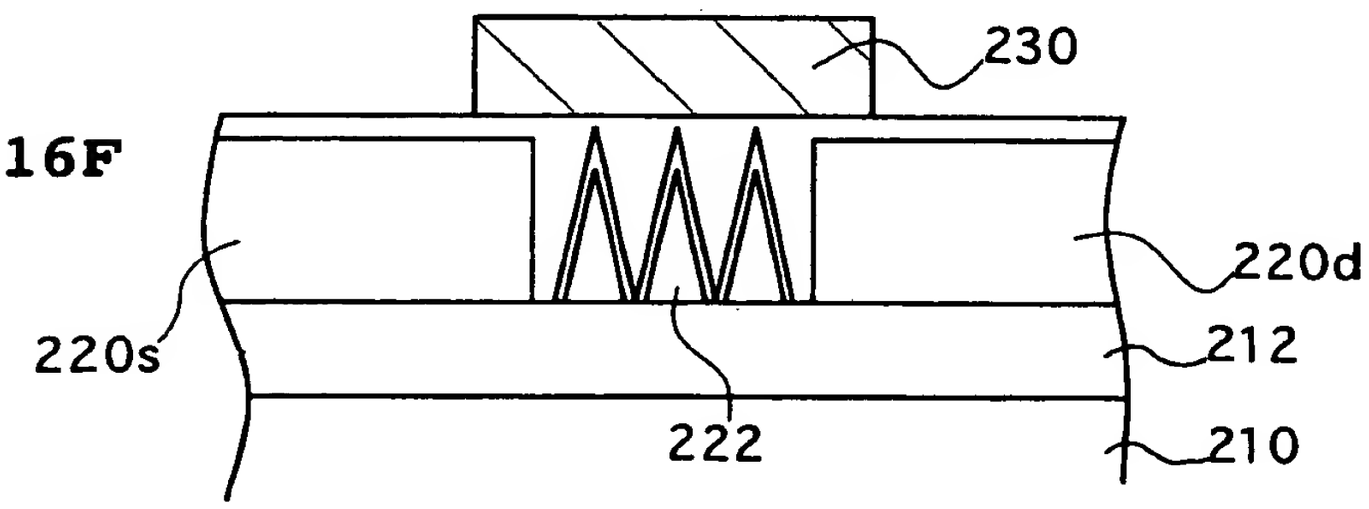


FIG. 16G

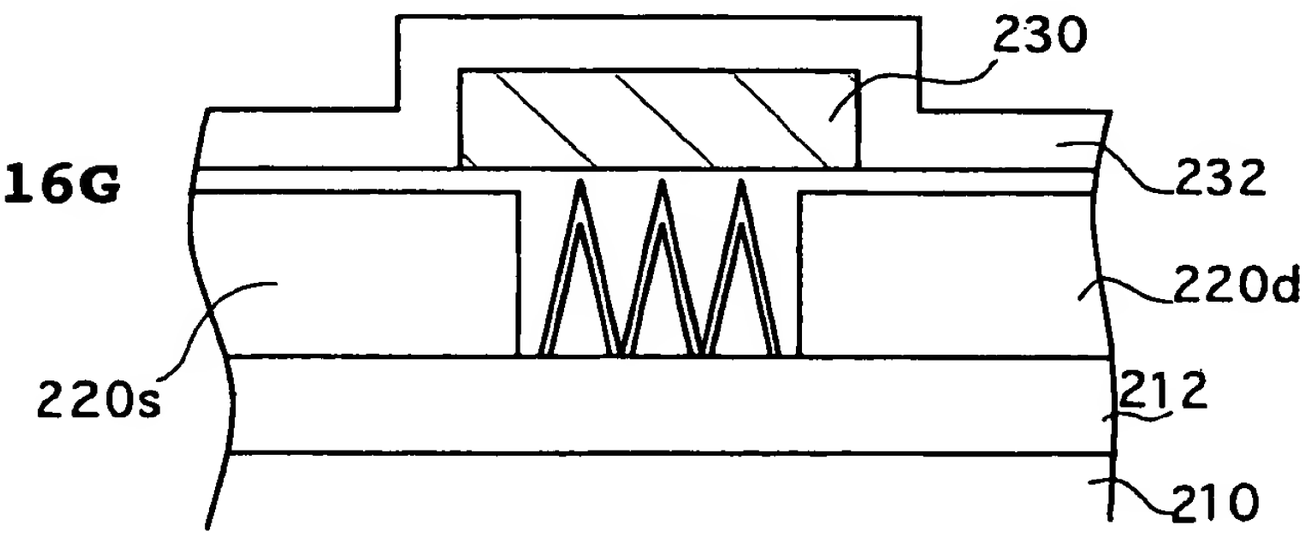


FIG. 16H

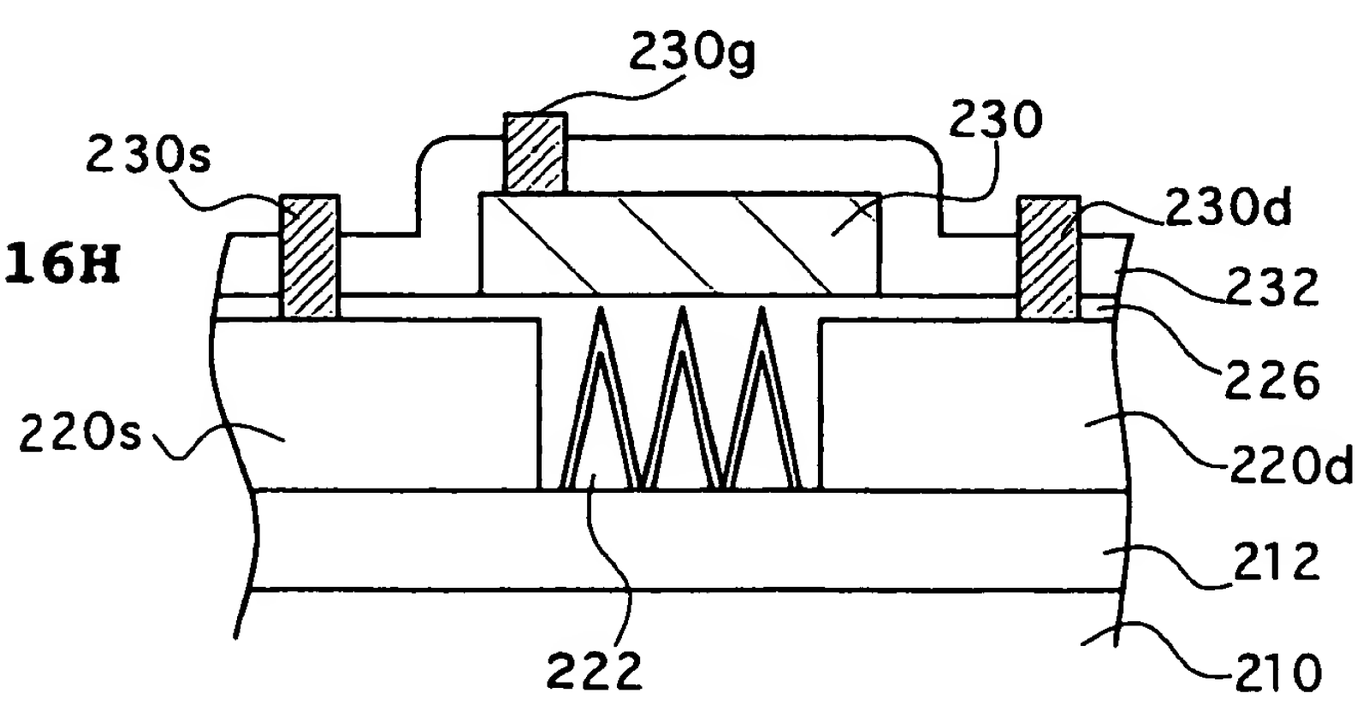


FIG. 17A

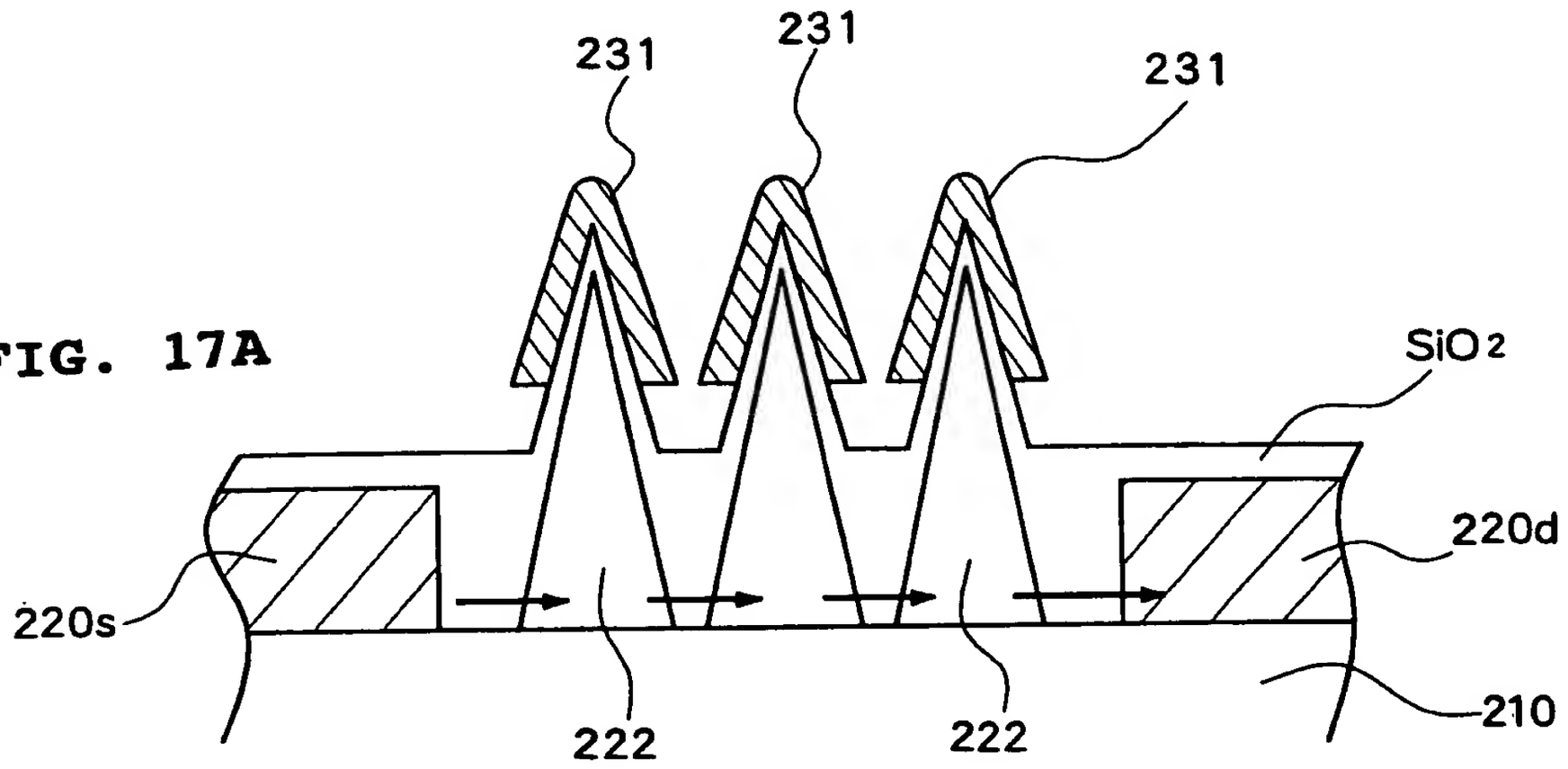


FIG. 17B

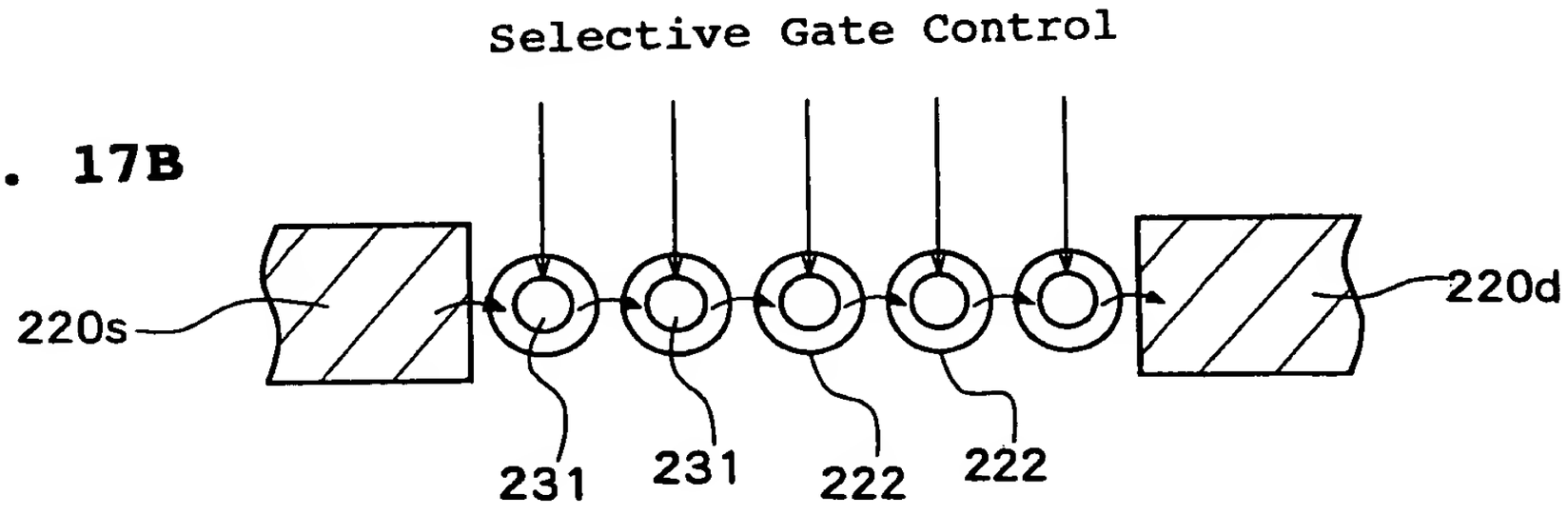
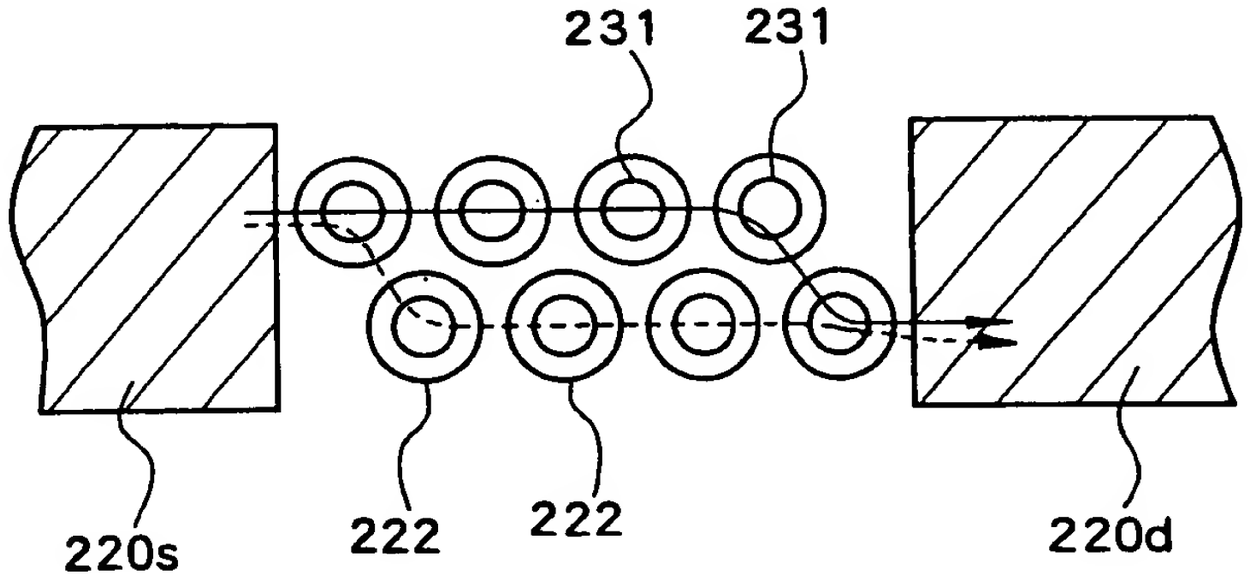


FIG. 17C



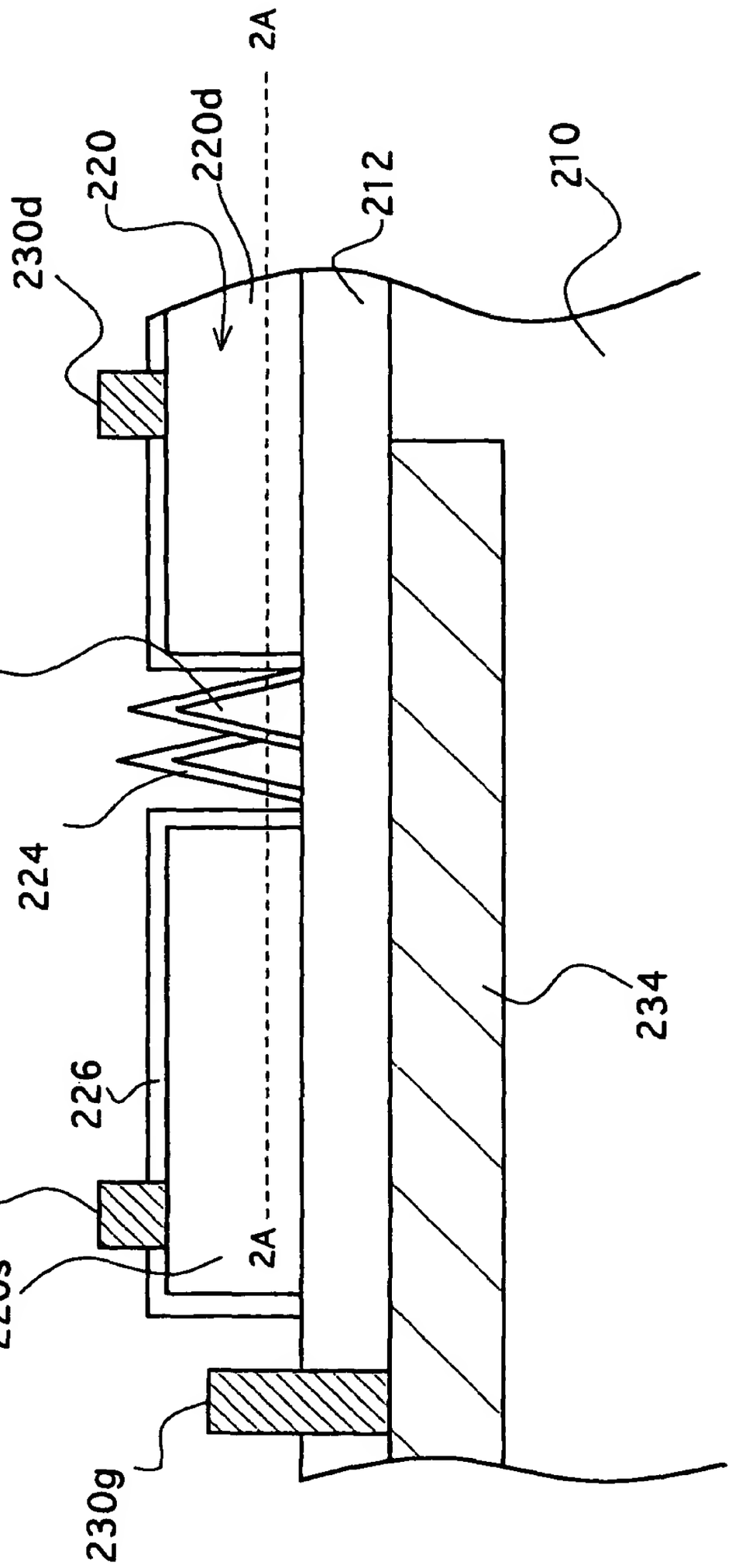


FIG. 18

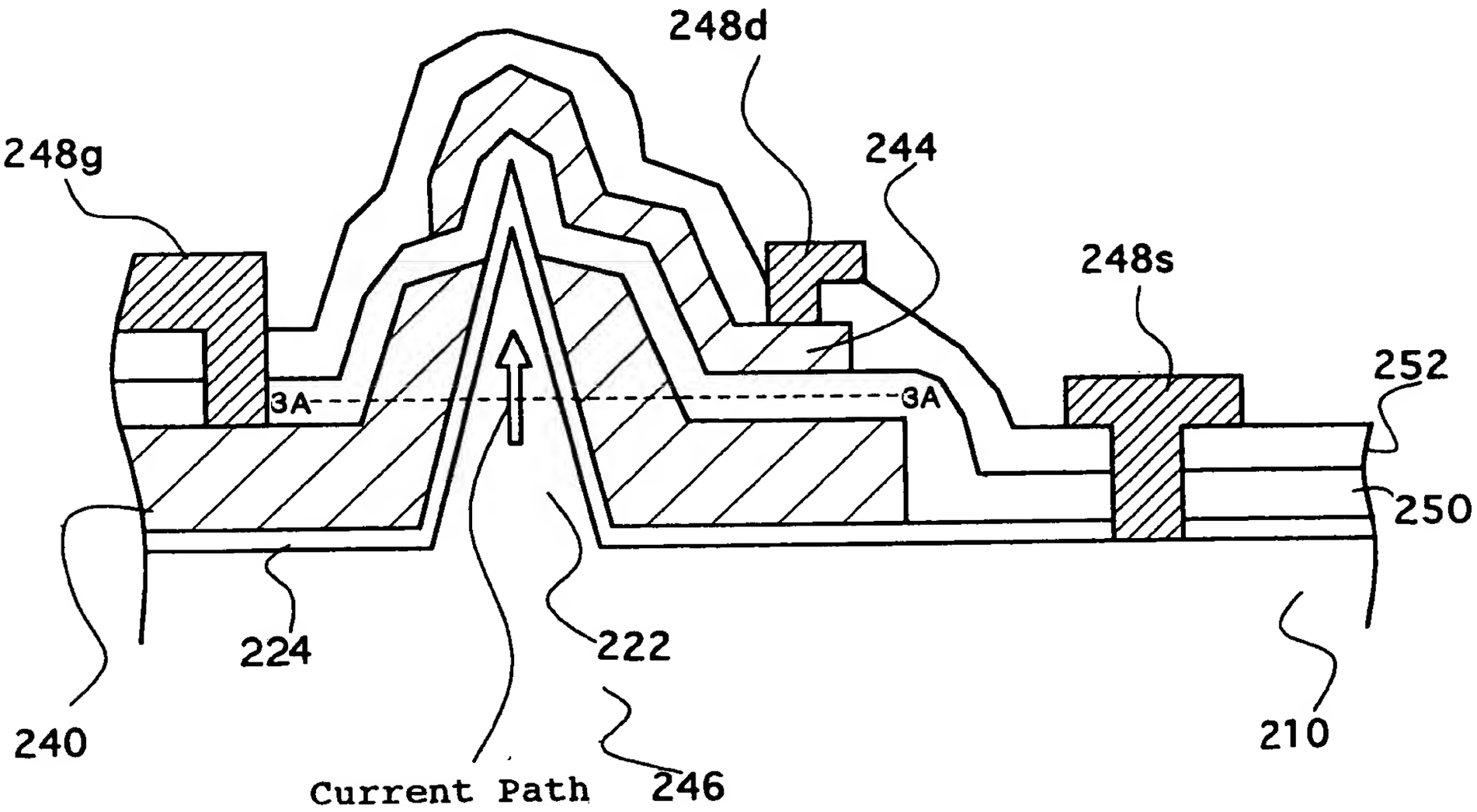


FIG. 19A

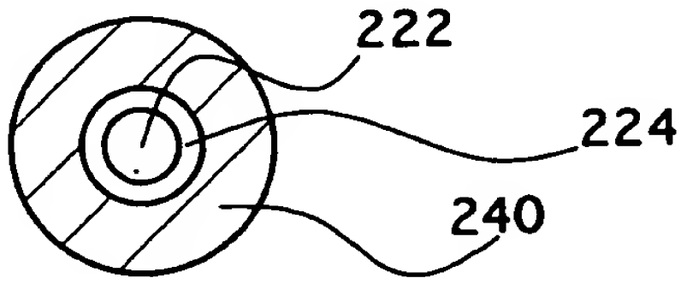


FIG. 19B

FIG. 20A

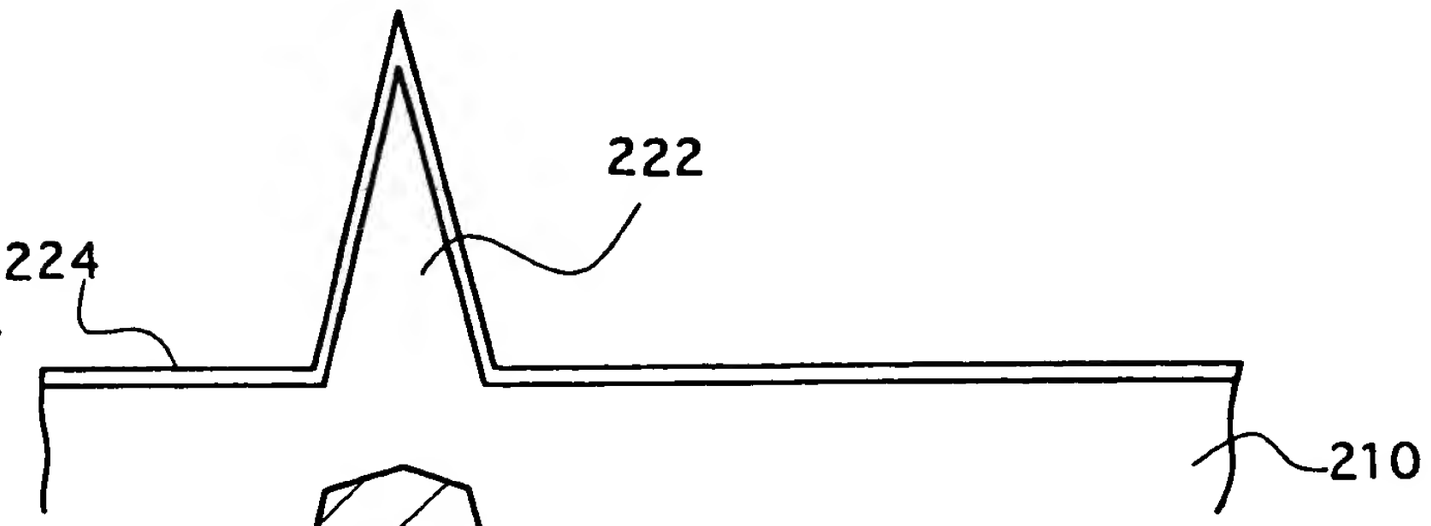


FIG. 20B

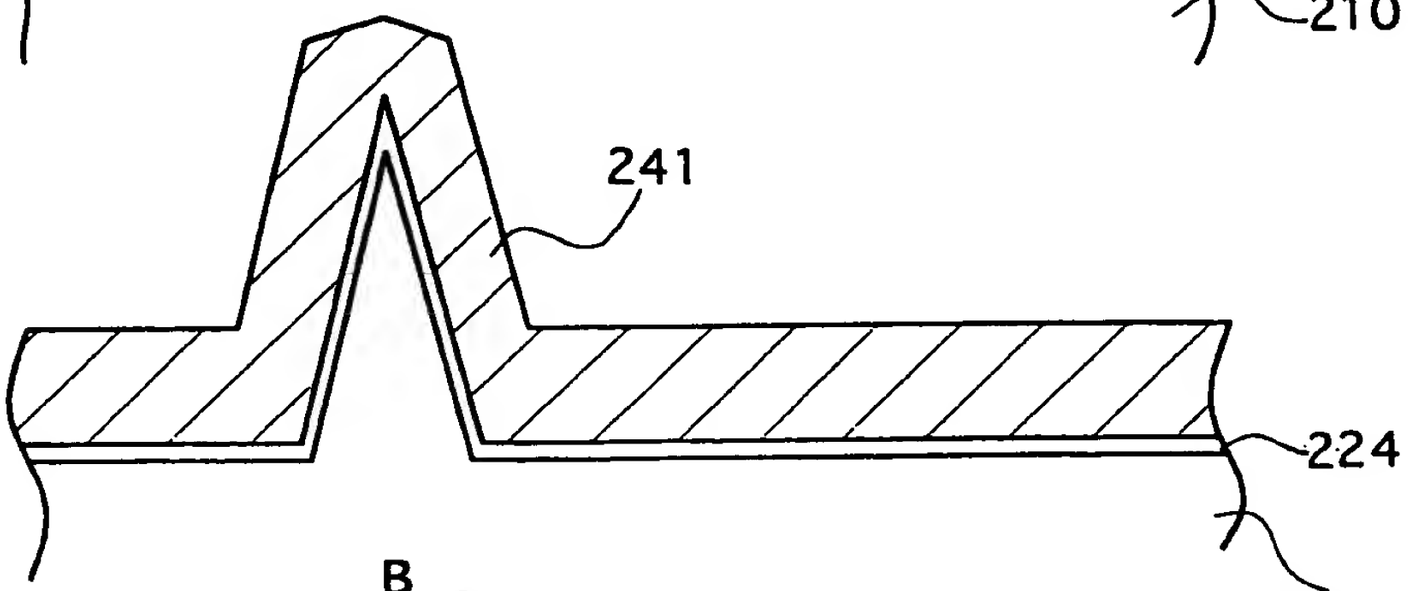


FIG. 20C

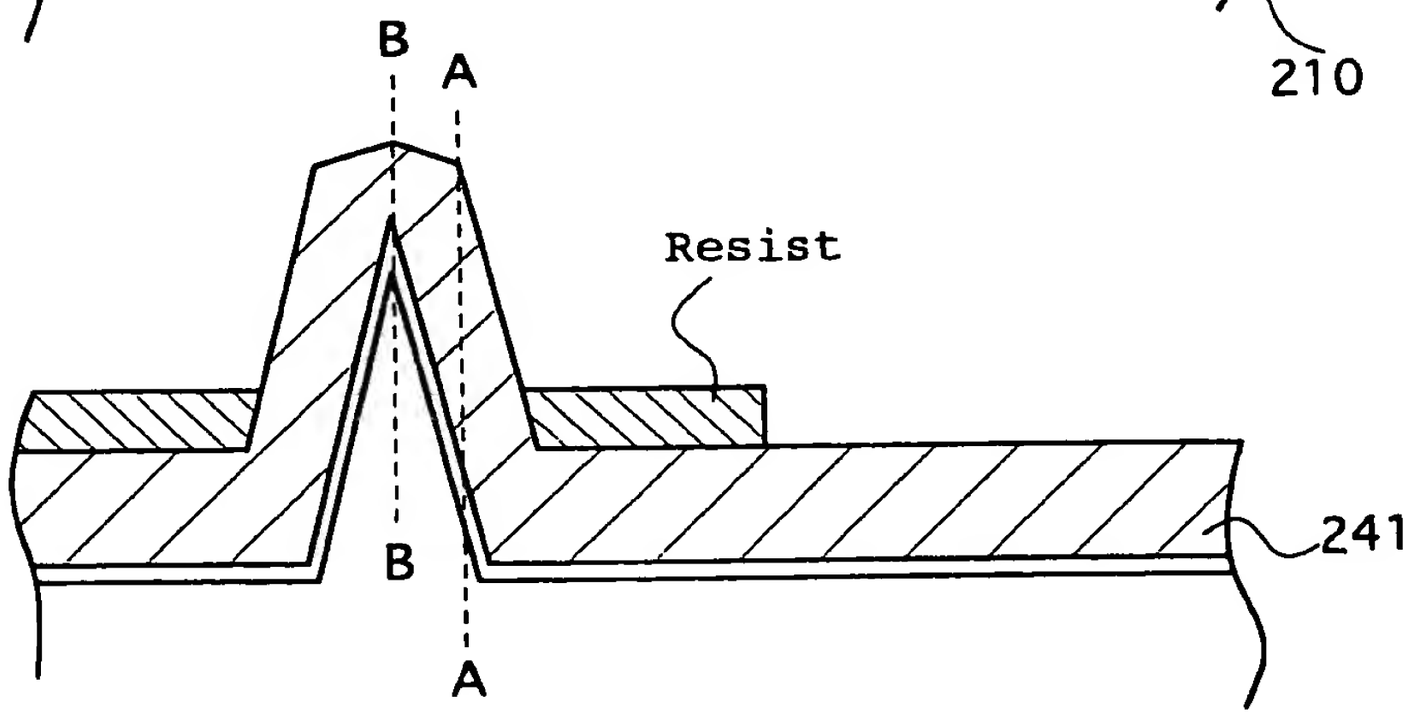


FIG. 20D

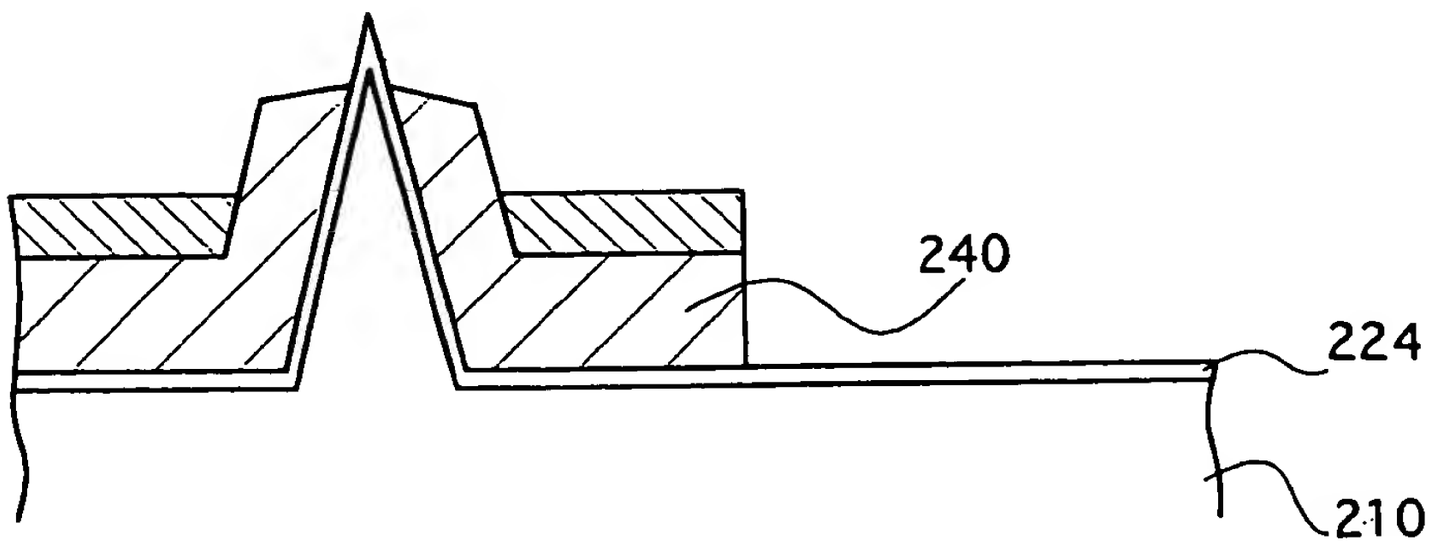


FIG. 20E

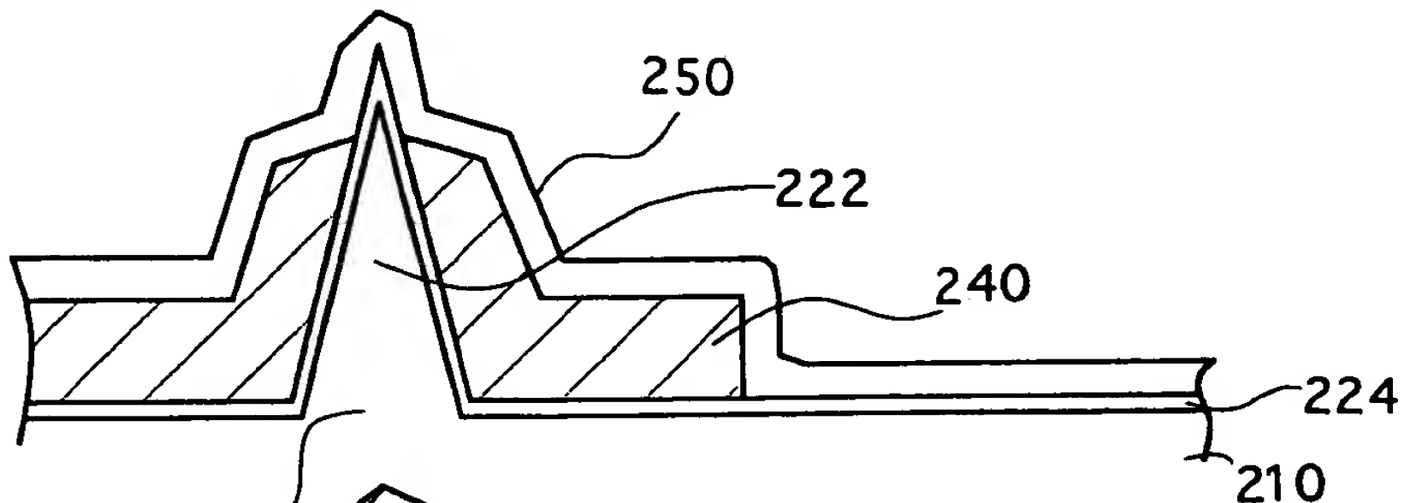


FIG. 20F

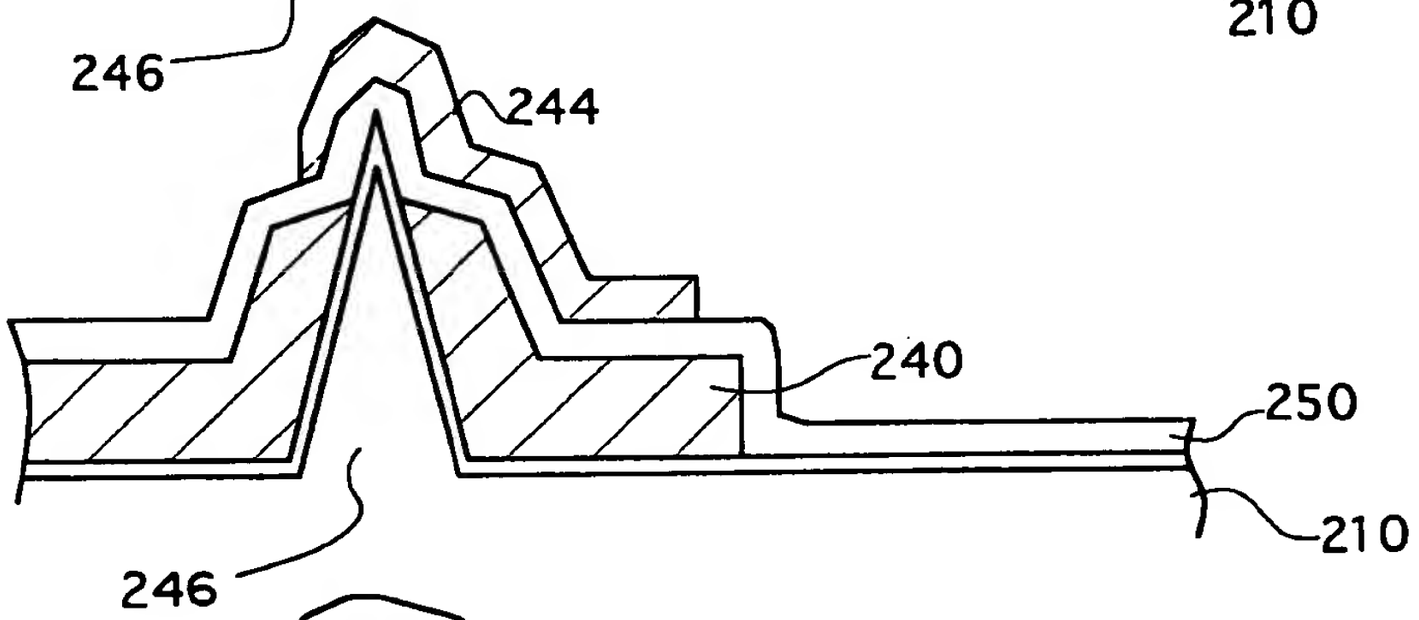


FIG. 20G

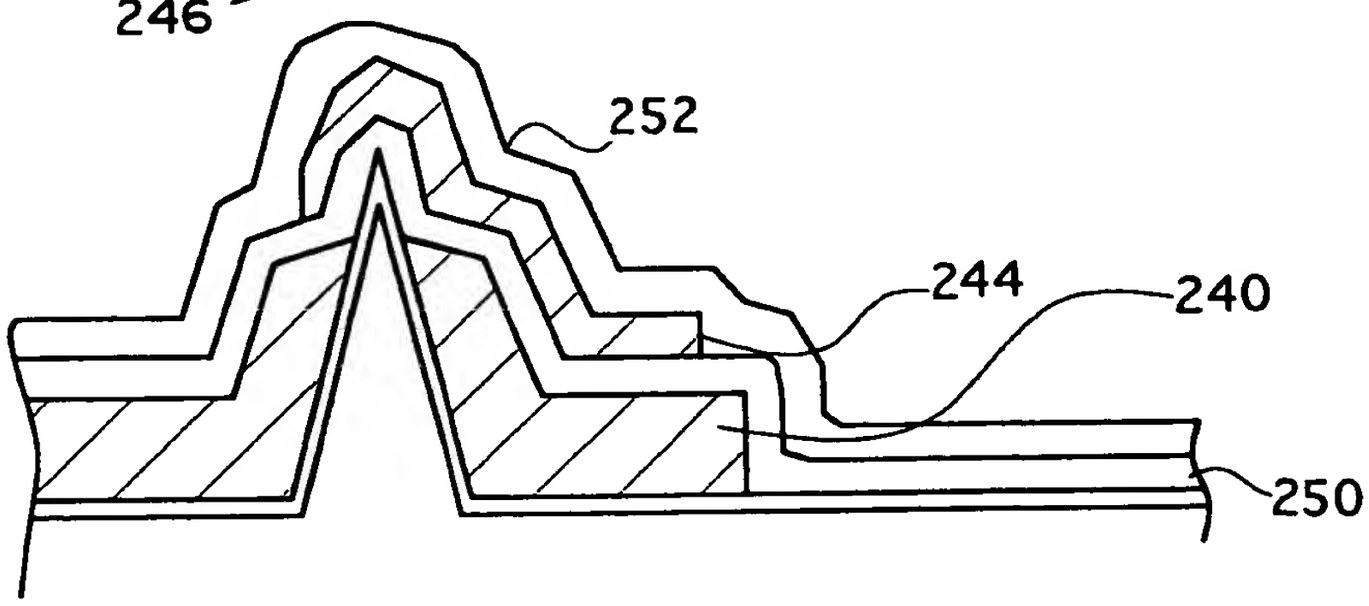
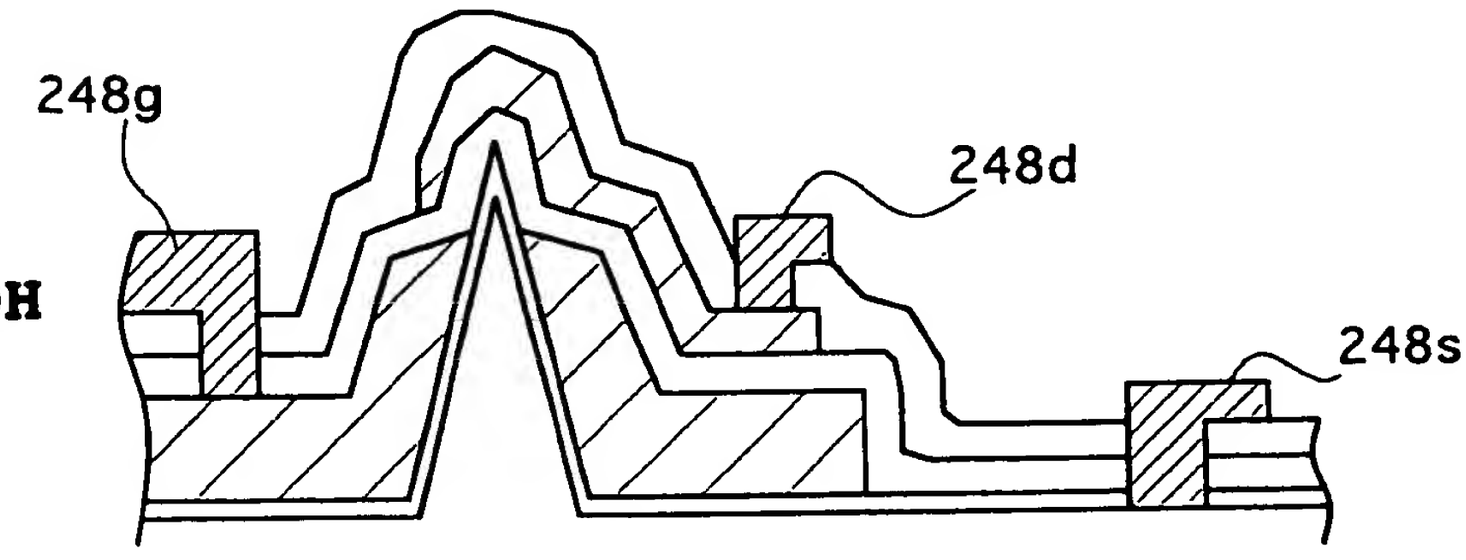


FIG. 20H



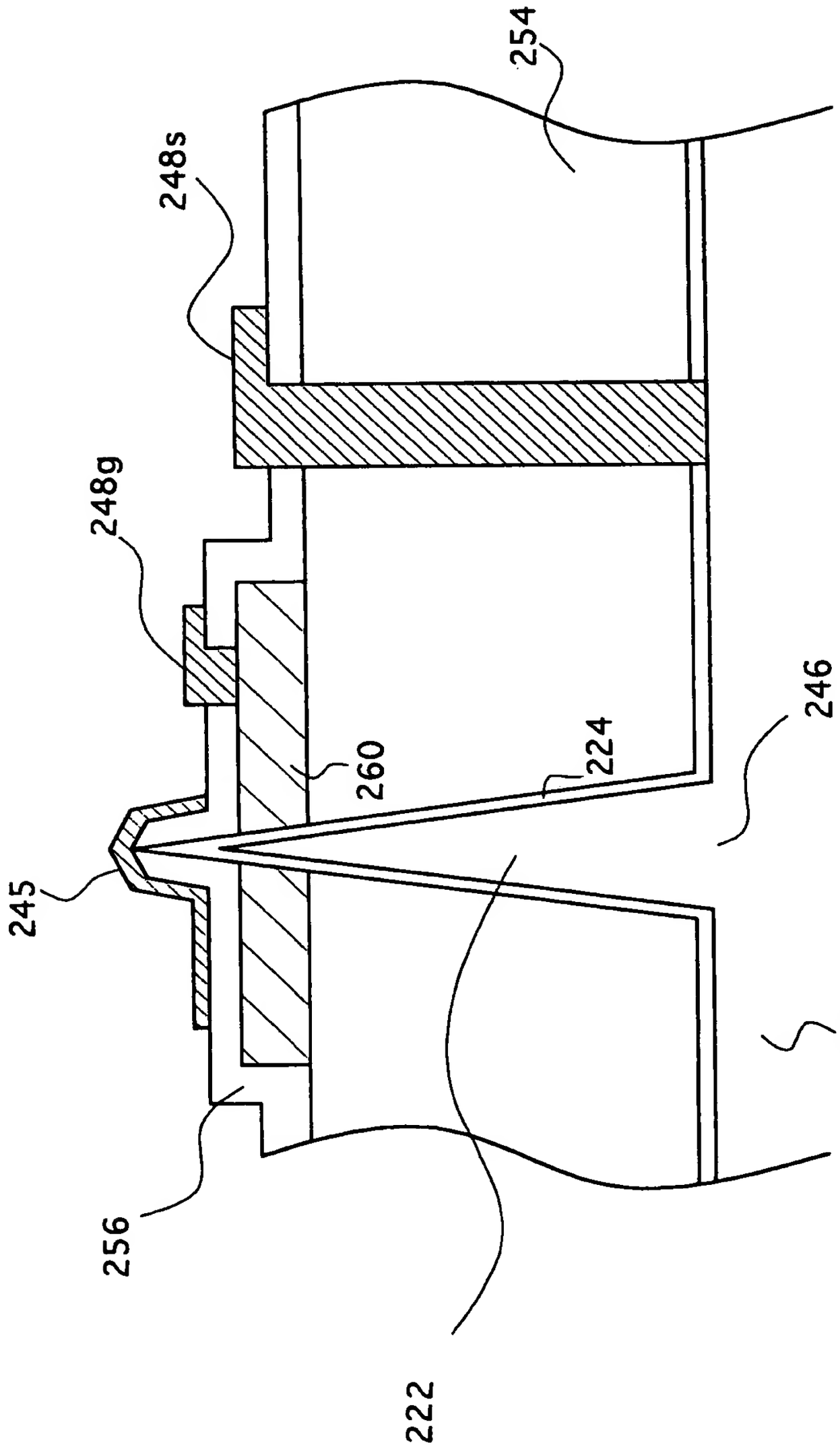


FIG. 21

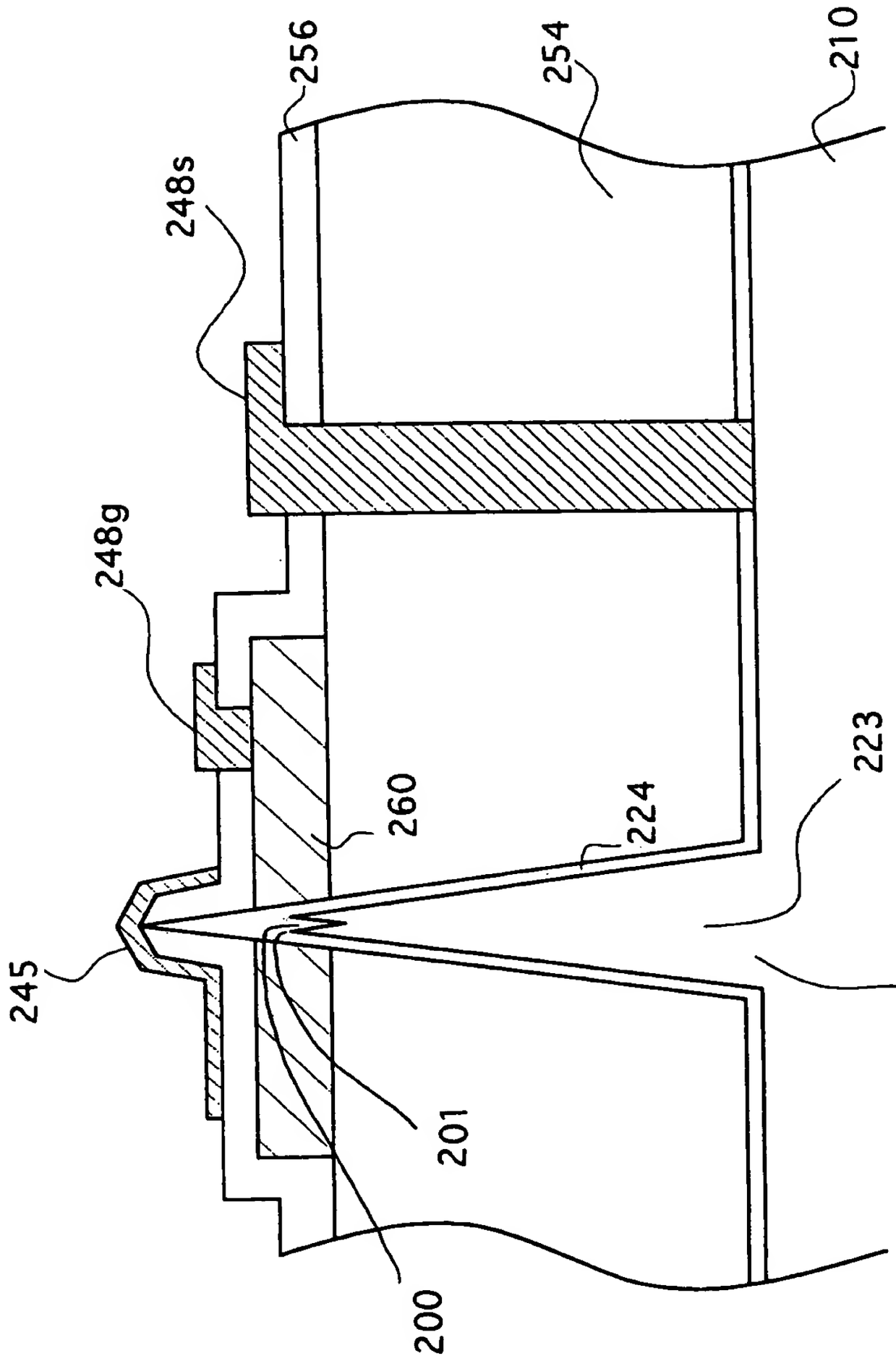


FIG. 22

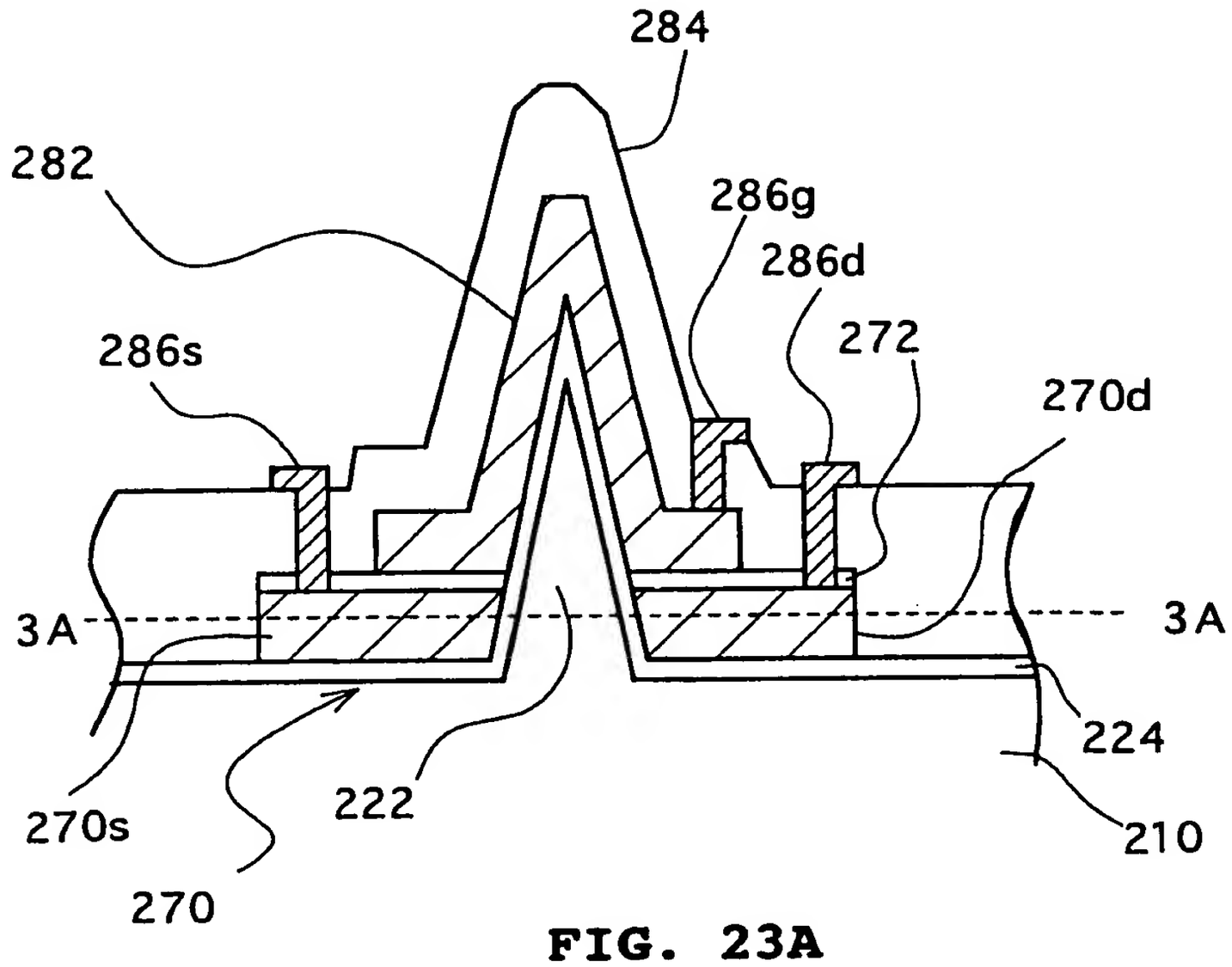


FIG. 23A

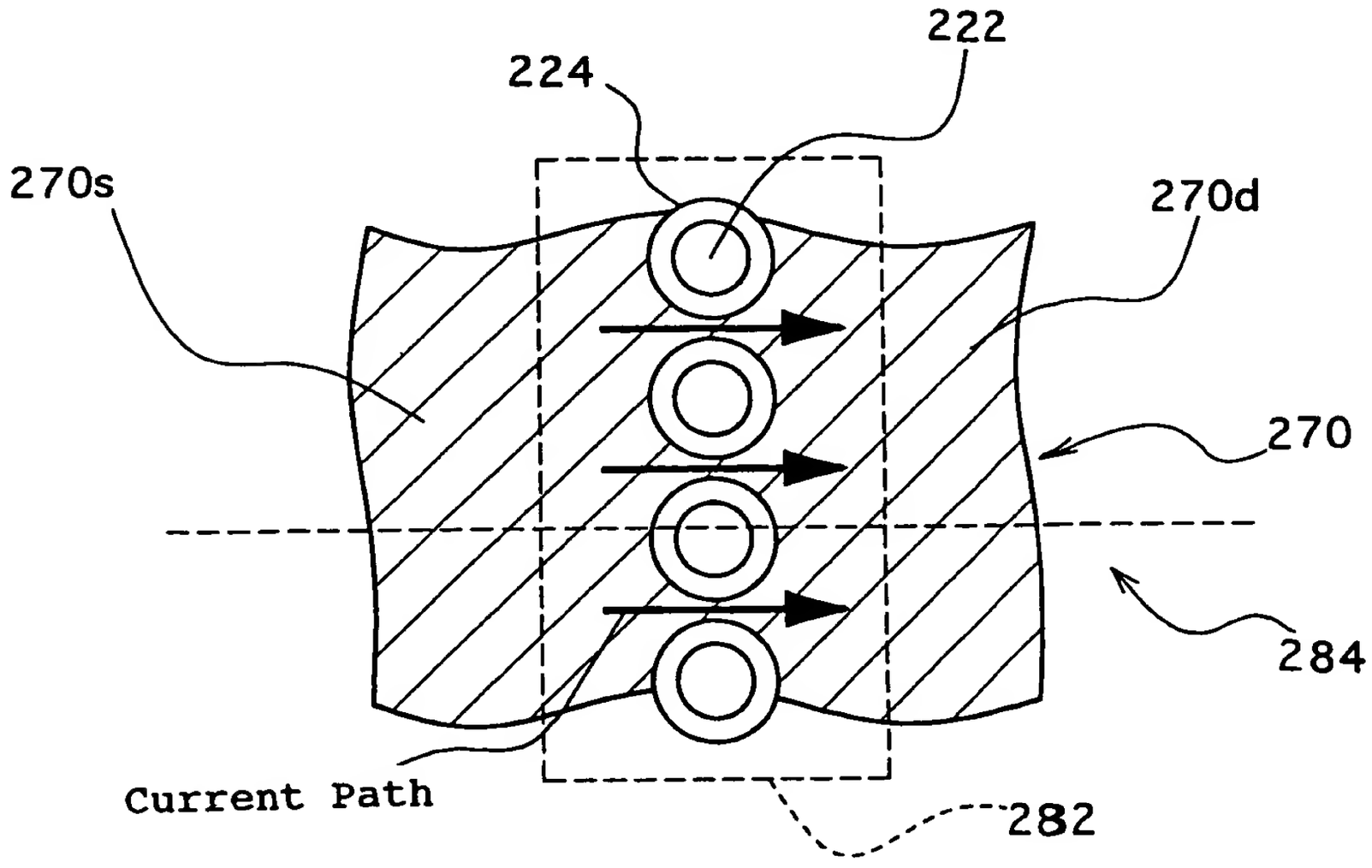


FIG. 23B

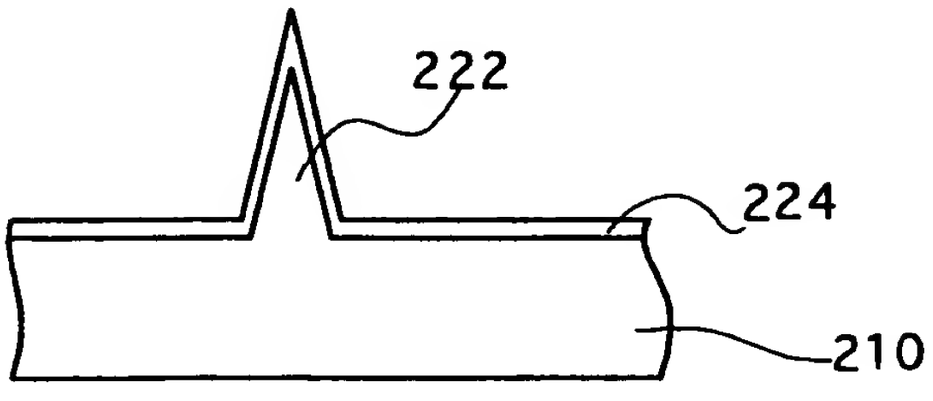


FIG. 24A

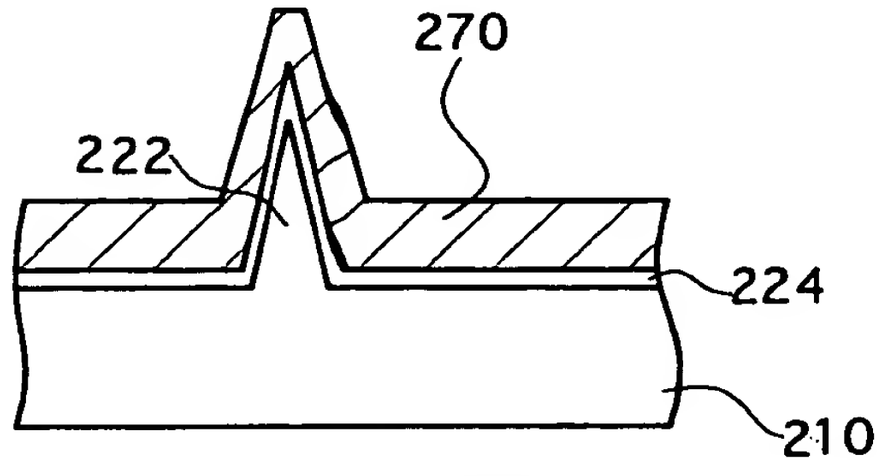


FIG. 24B

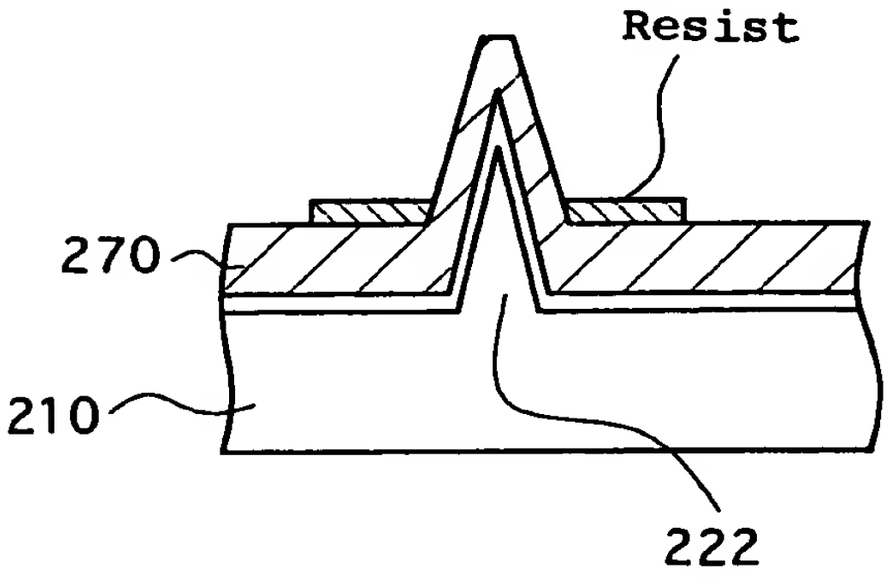


FIG. 24C

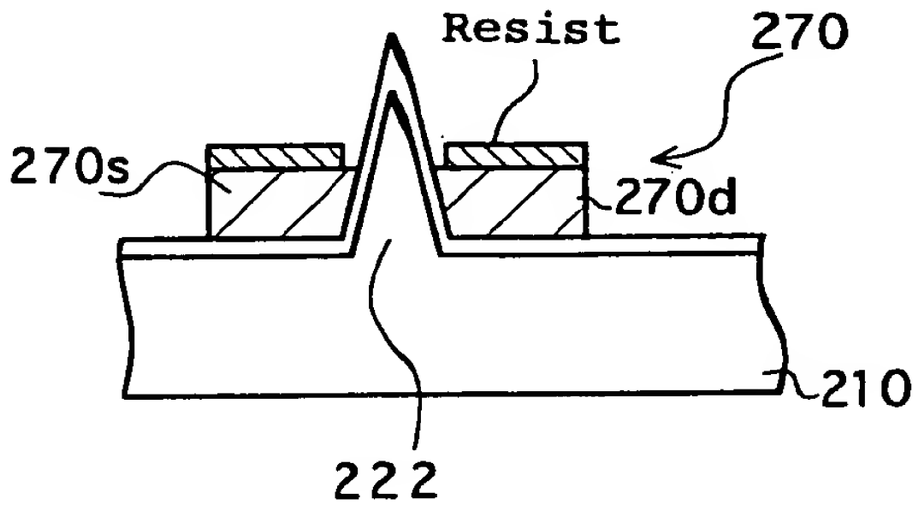


FIG. 24D

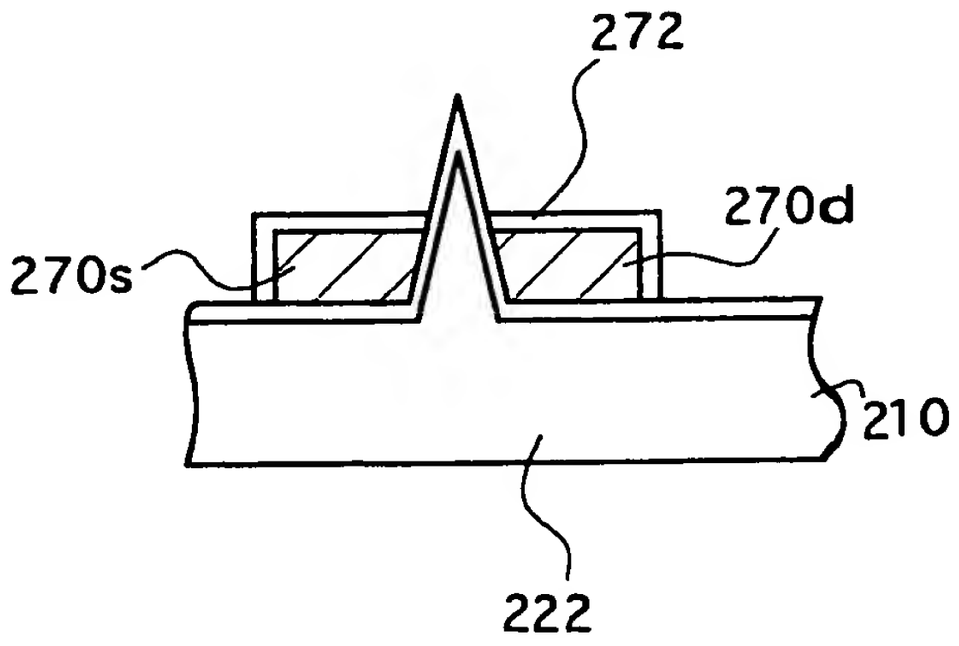


FIG. 24E

FIG. 24F

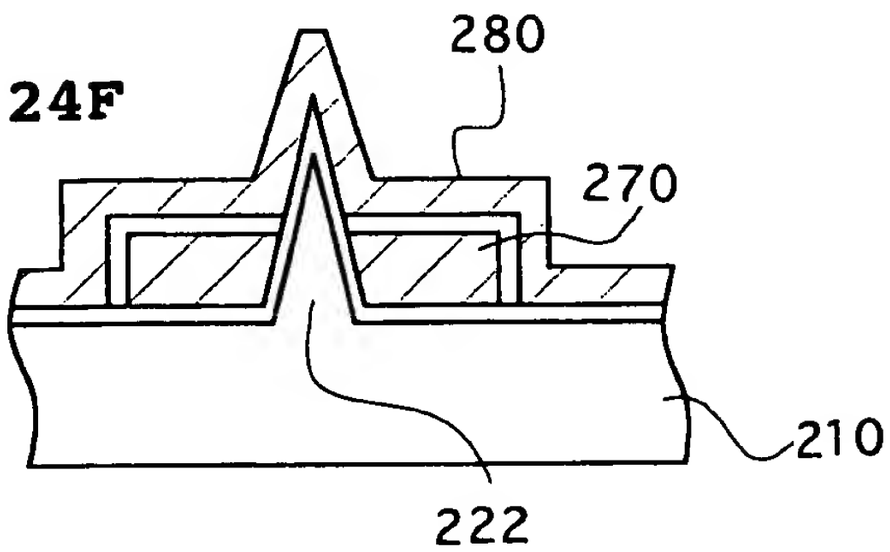


FIG. 24G

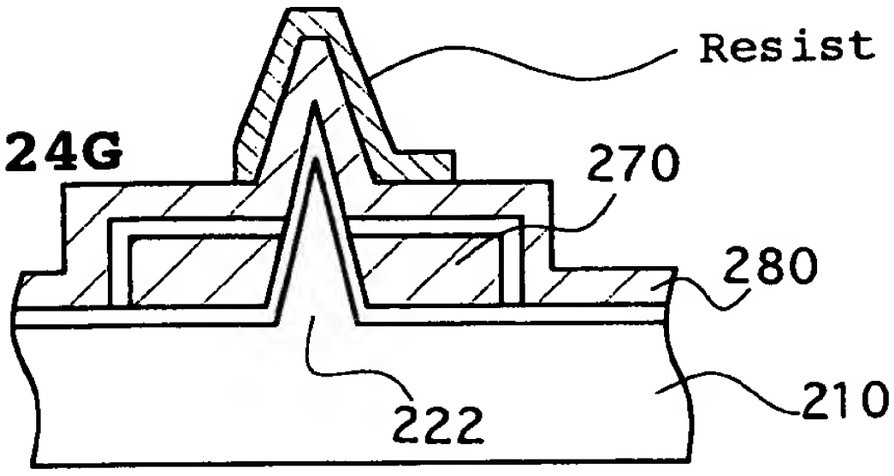


FIG. 24H

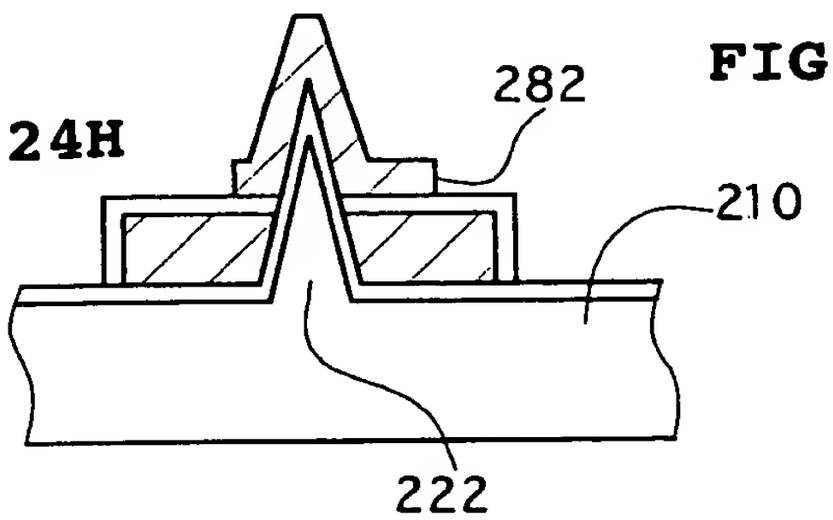


FIG. 24I

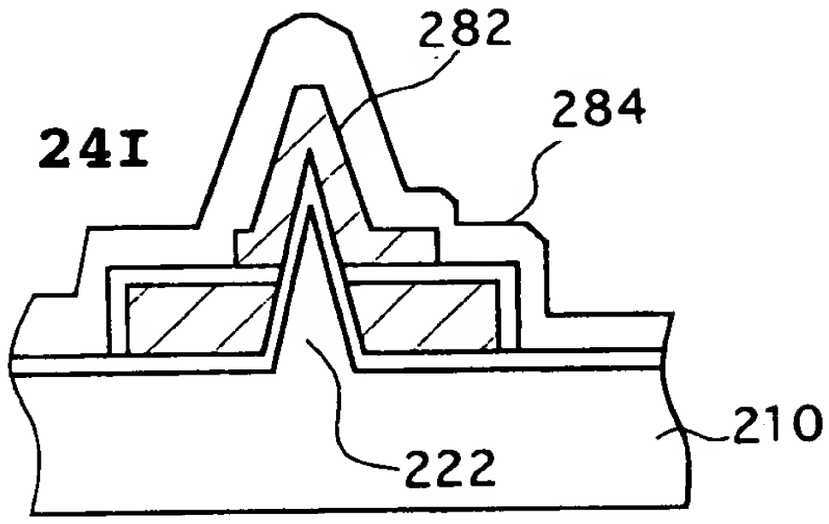
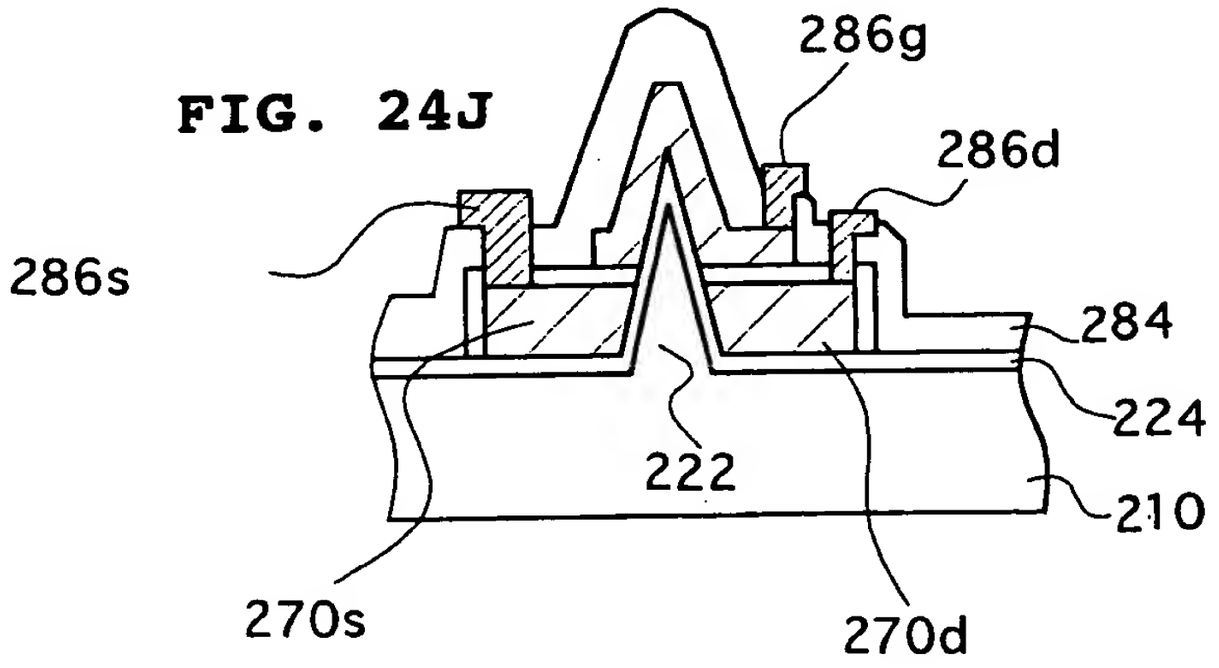


FIG. 24J



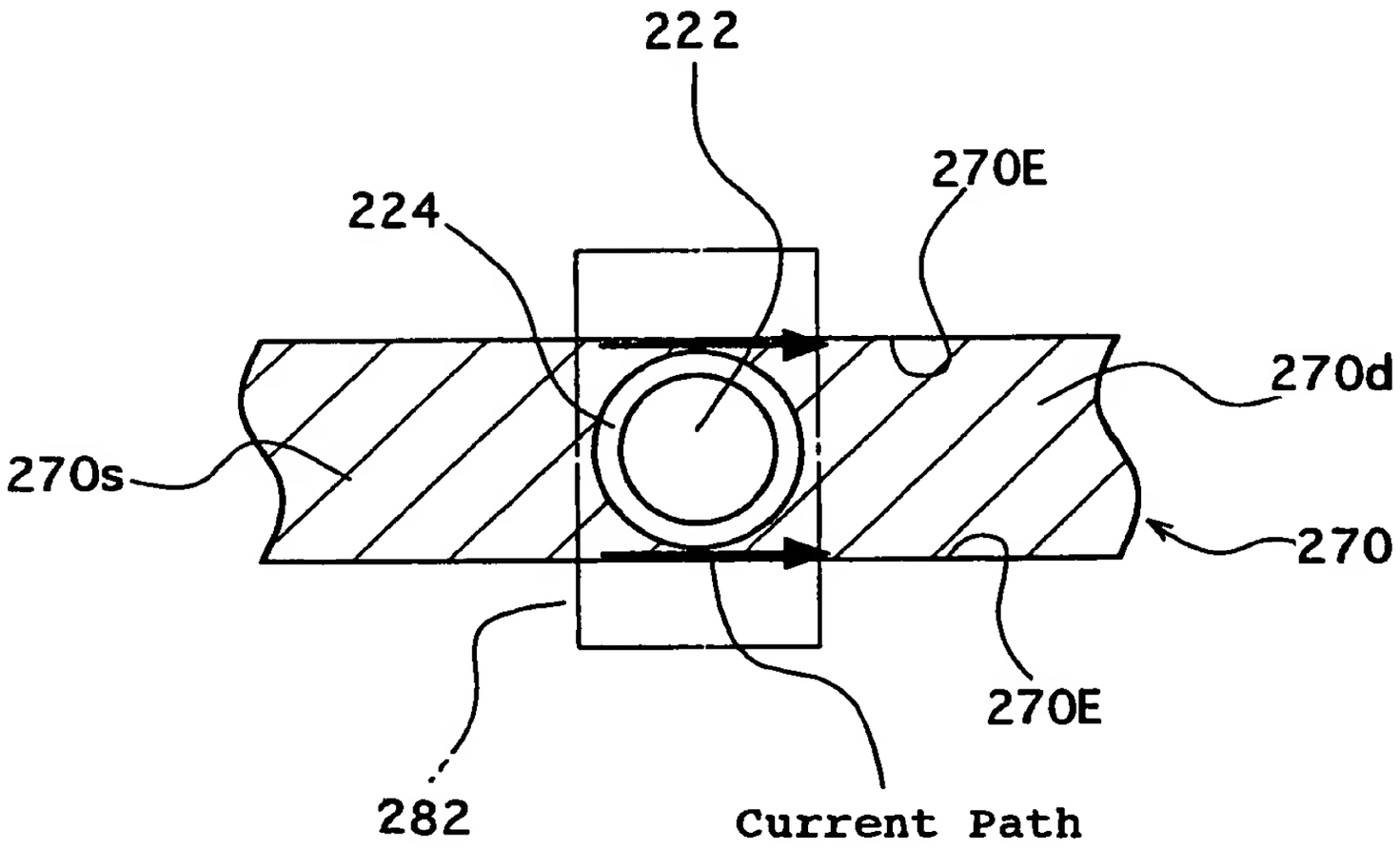


FIG. 25A

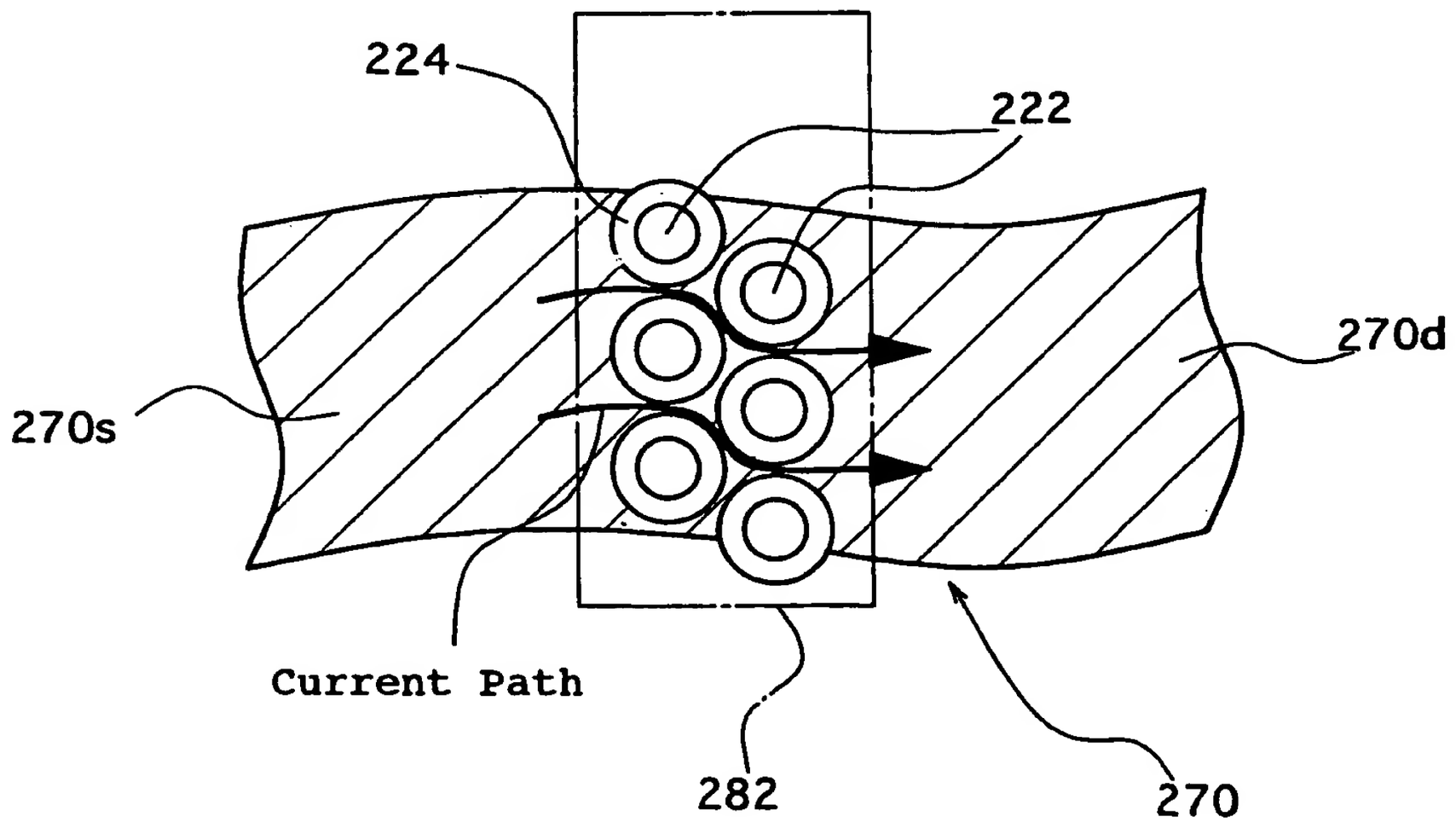


FIG. 25B

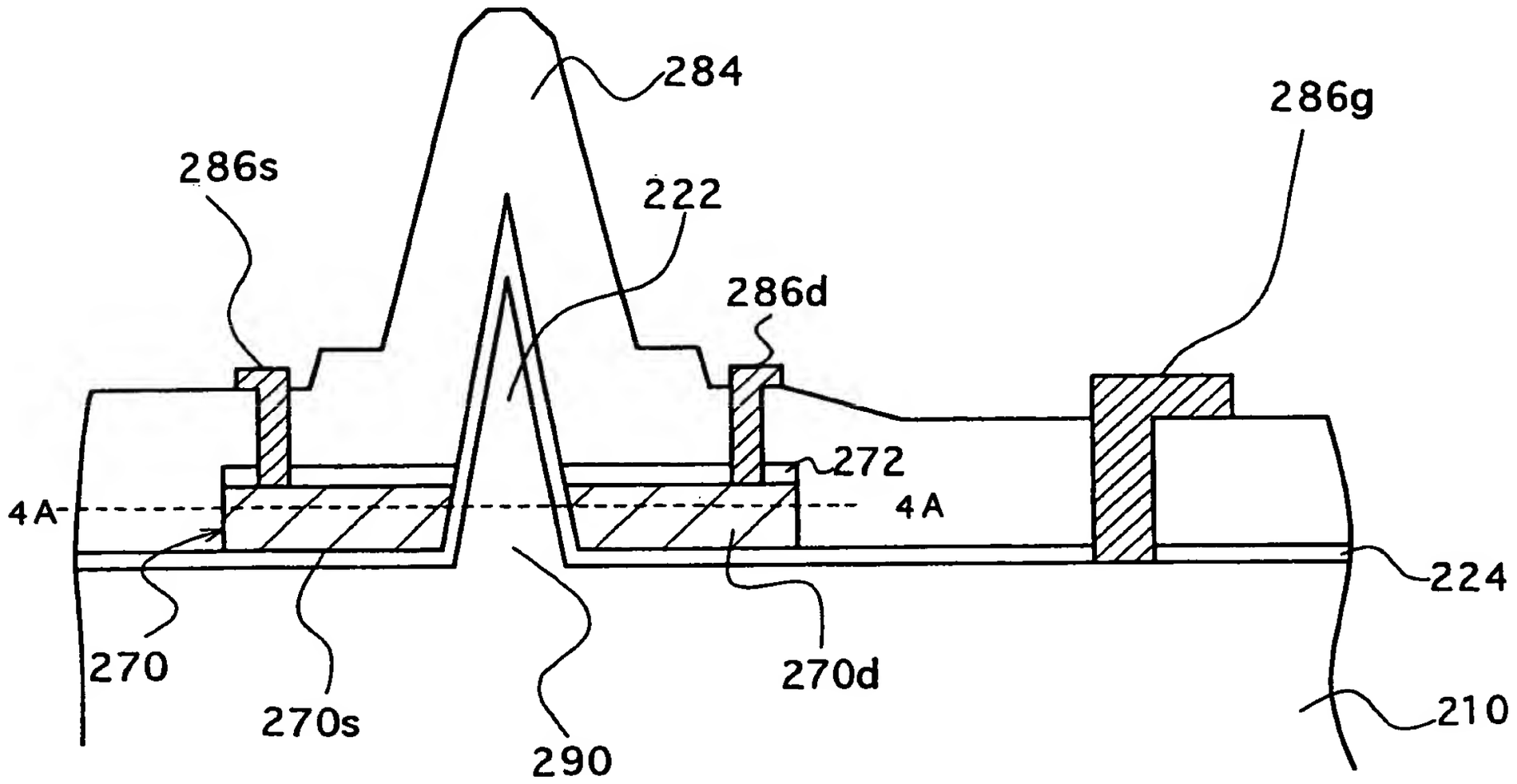


FIG. 26A

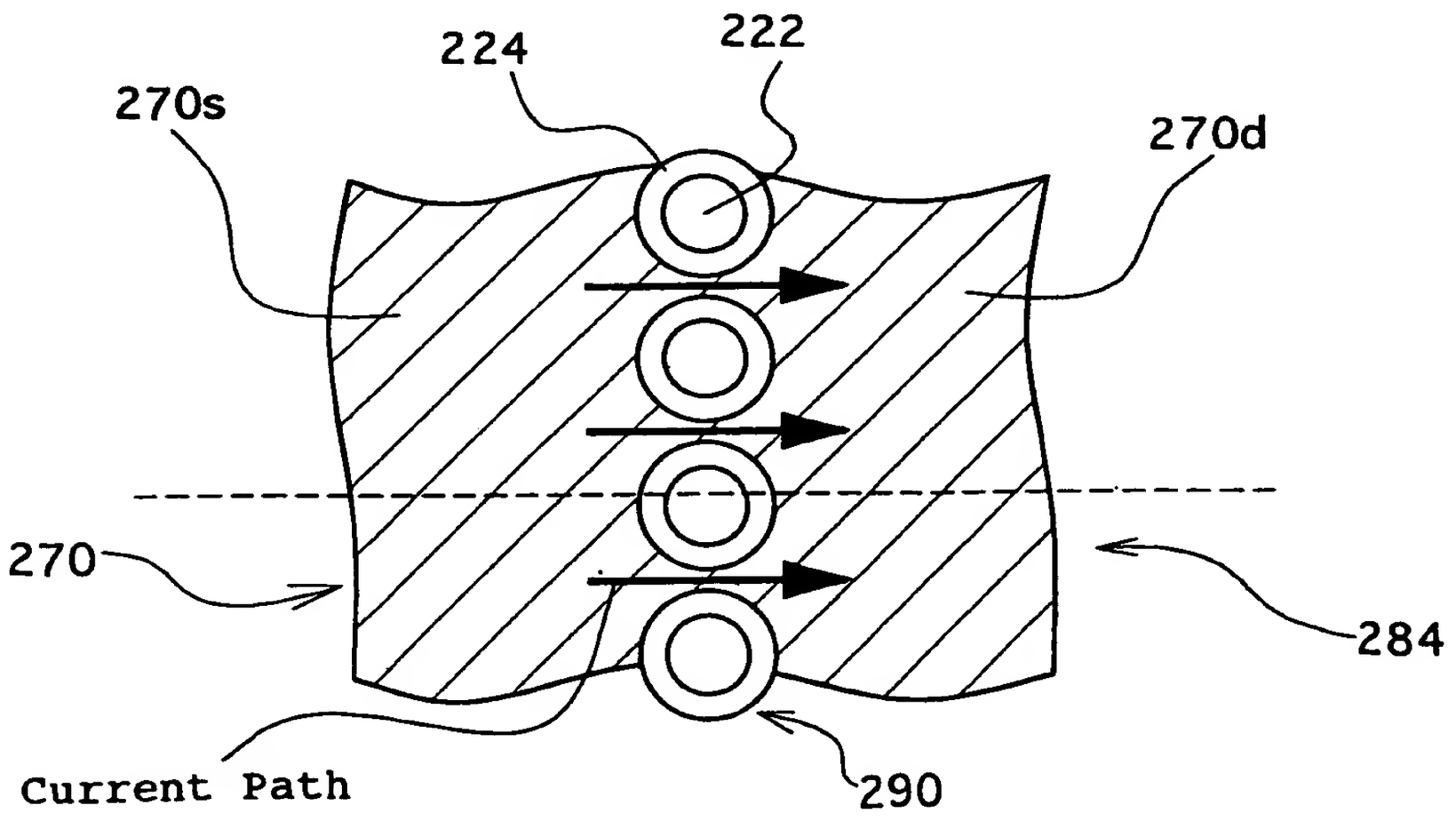


FIG. 26B

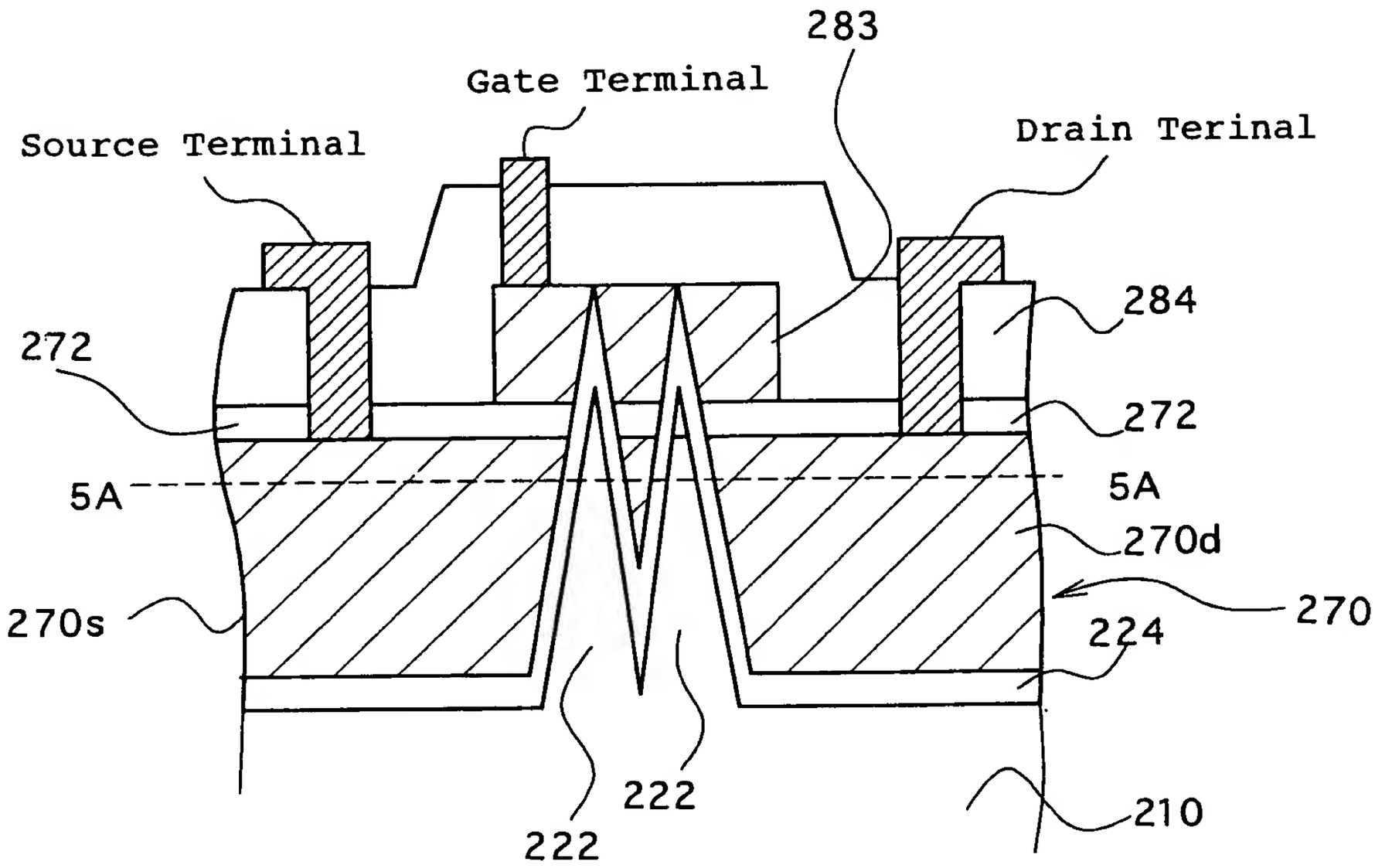


FIG. 27A

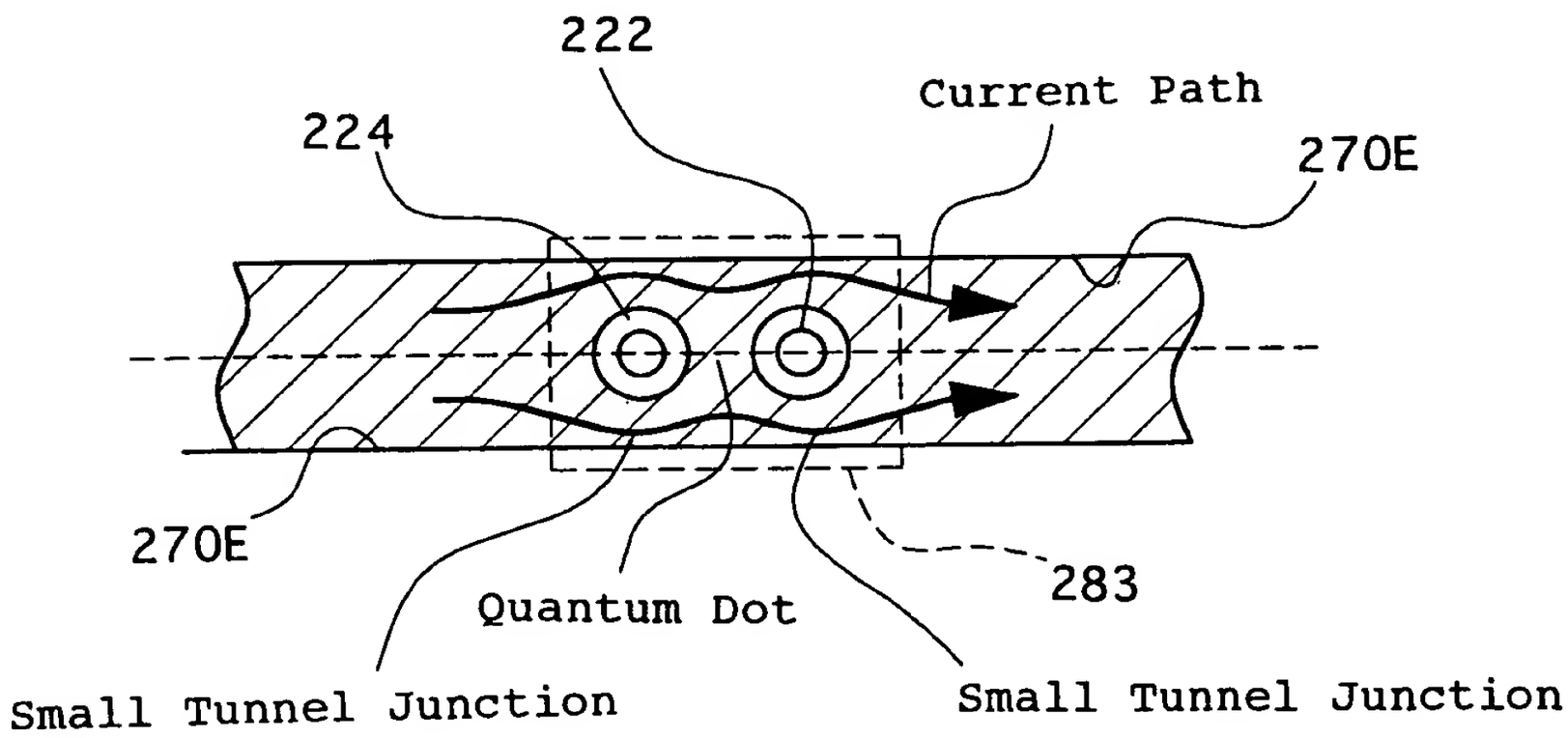


FIG. 27B

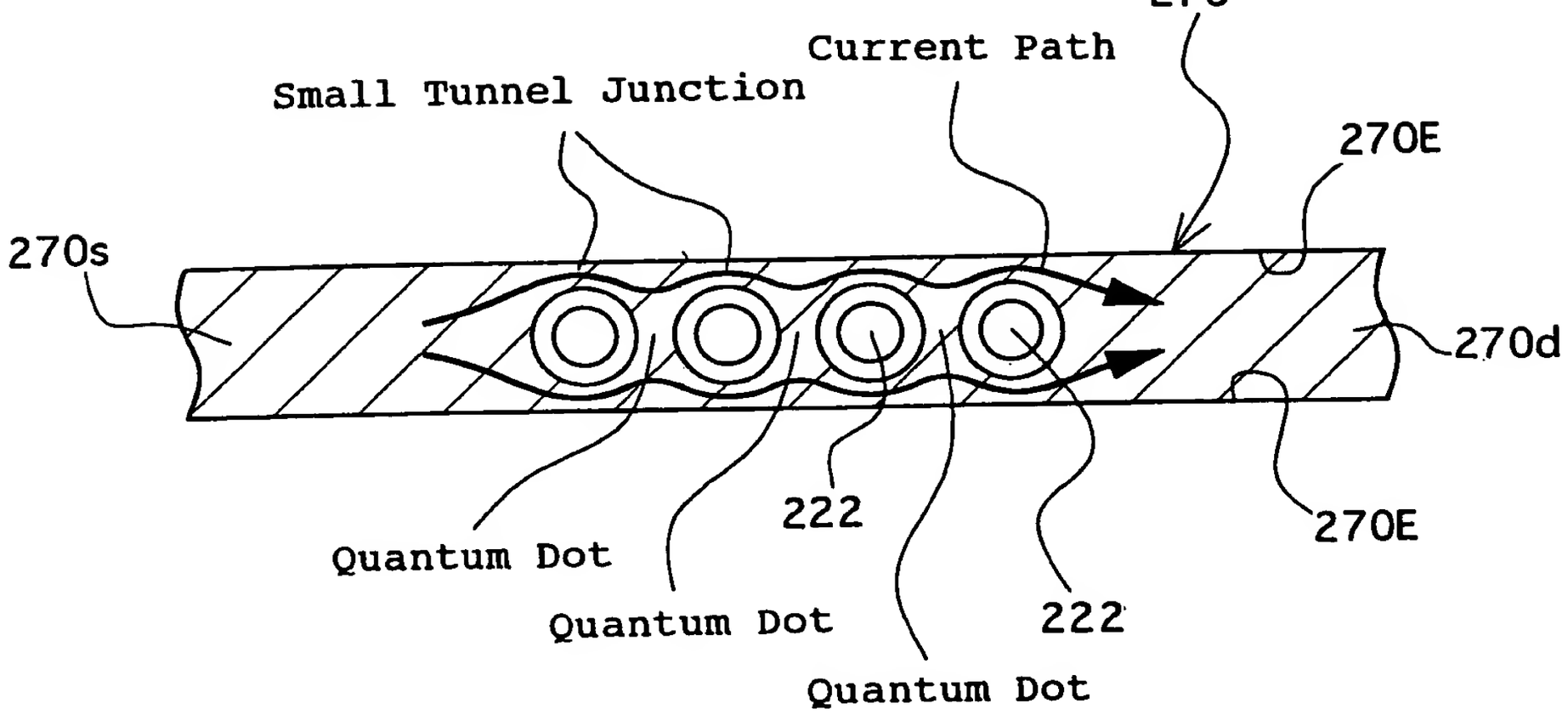

270
Current Path
Small Tunnel Junction
270E
270s
270d
222
Quantum Dot
270E
Quantum Dot
222
Quantum Dot

FIG. 28

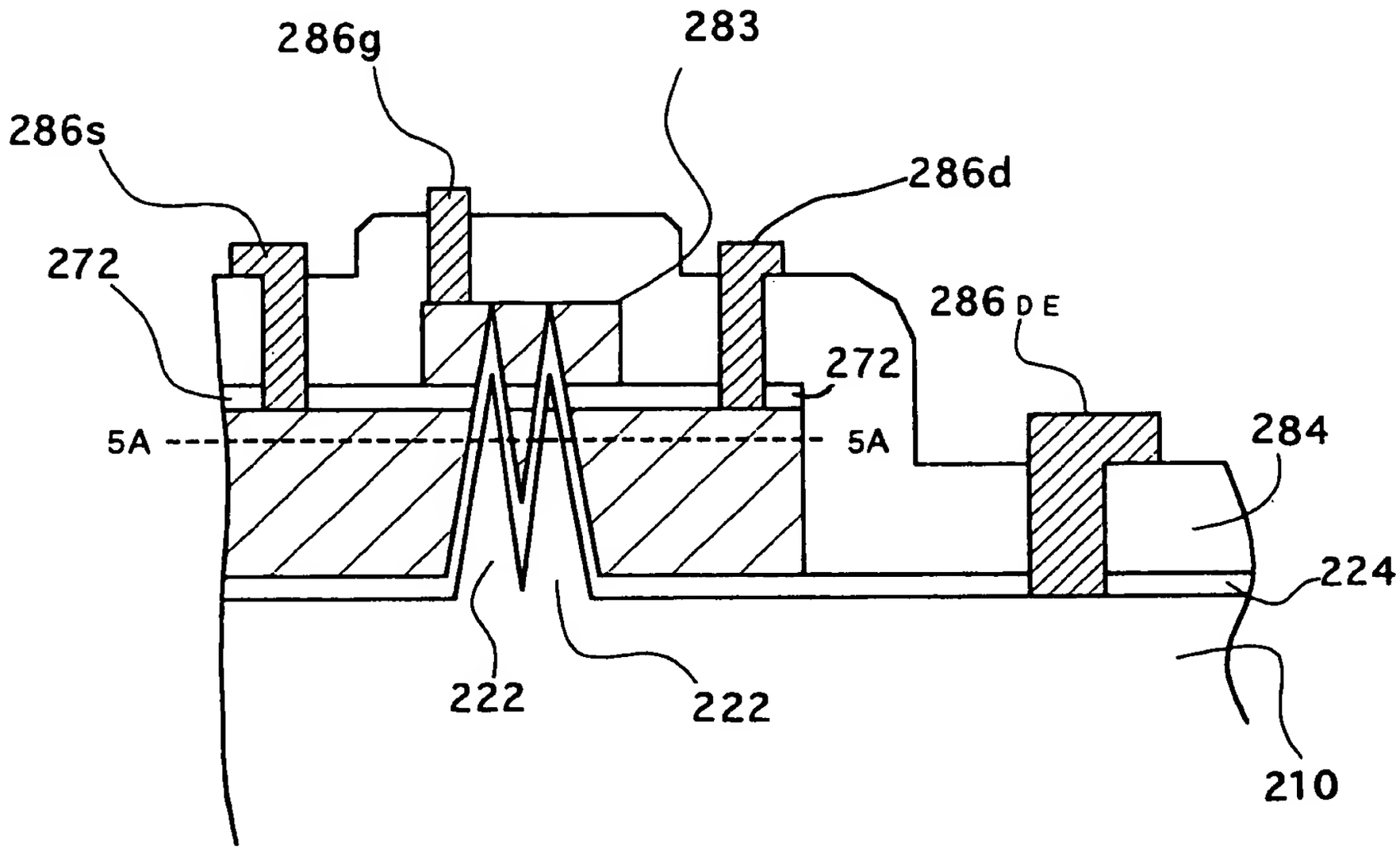


FIG. 29A

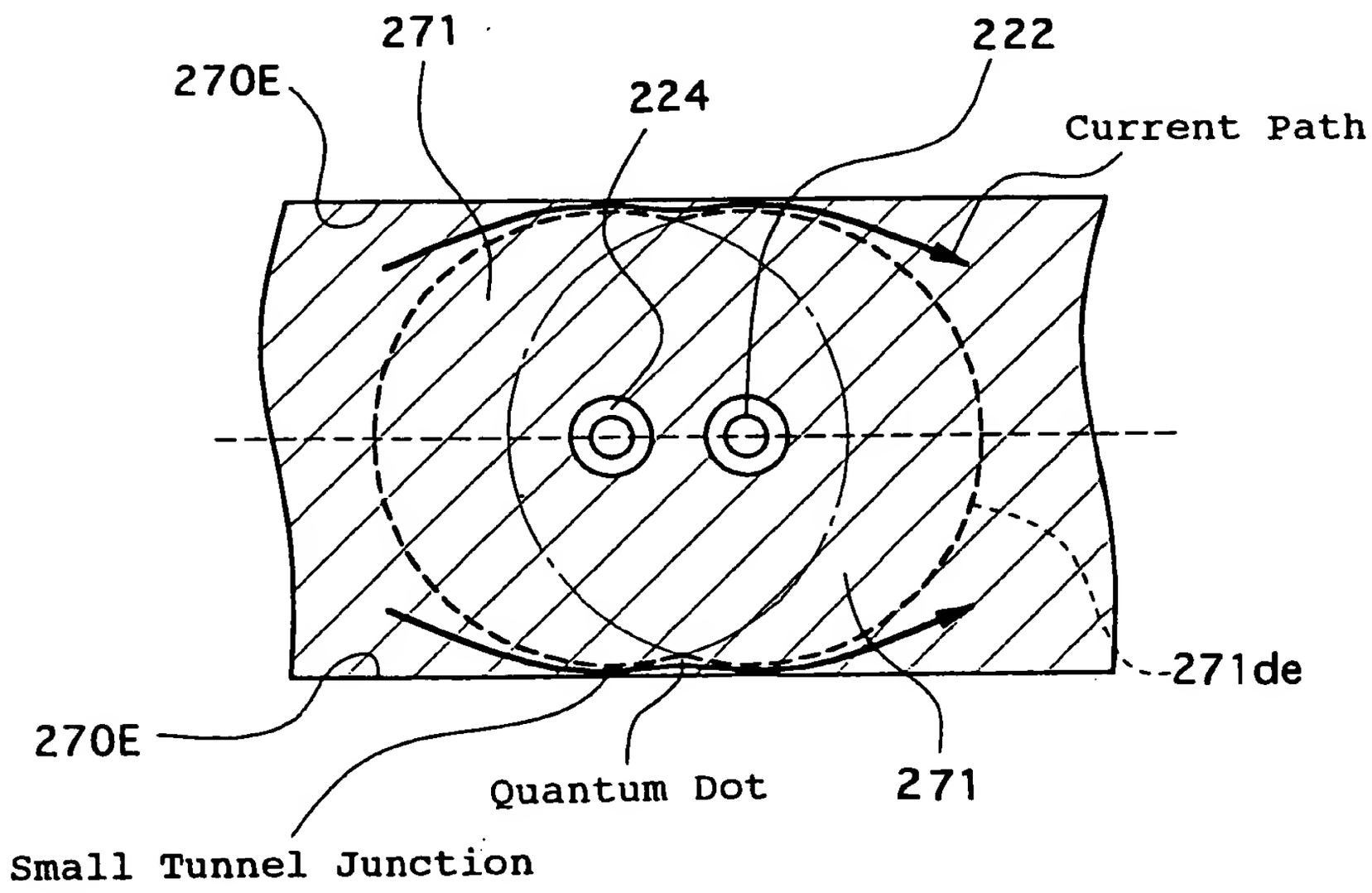


FIG. 29B

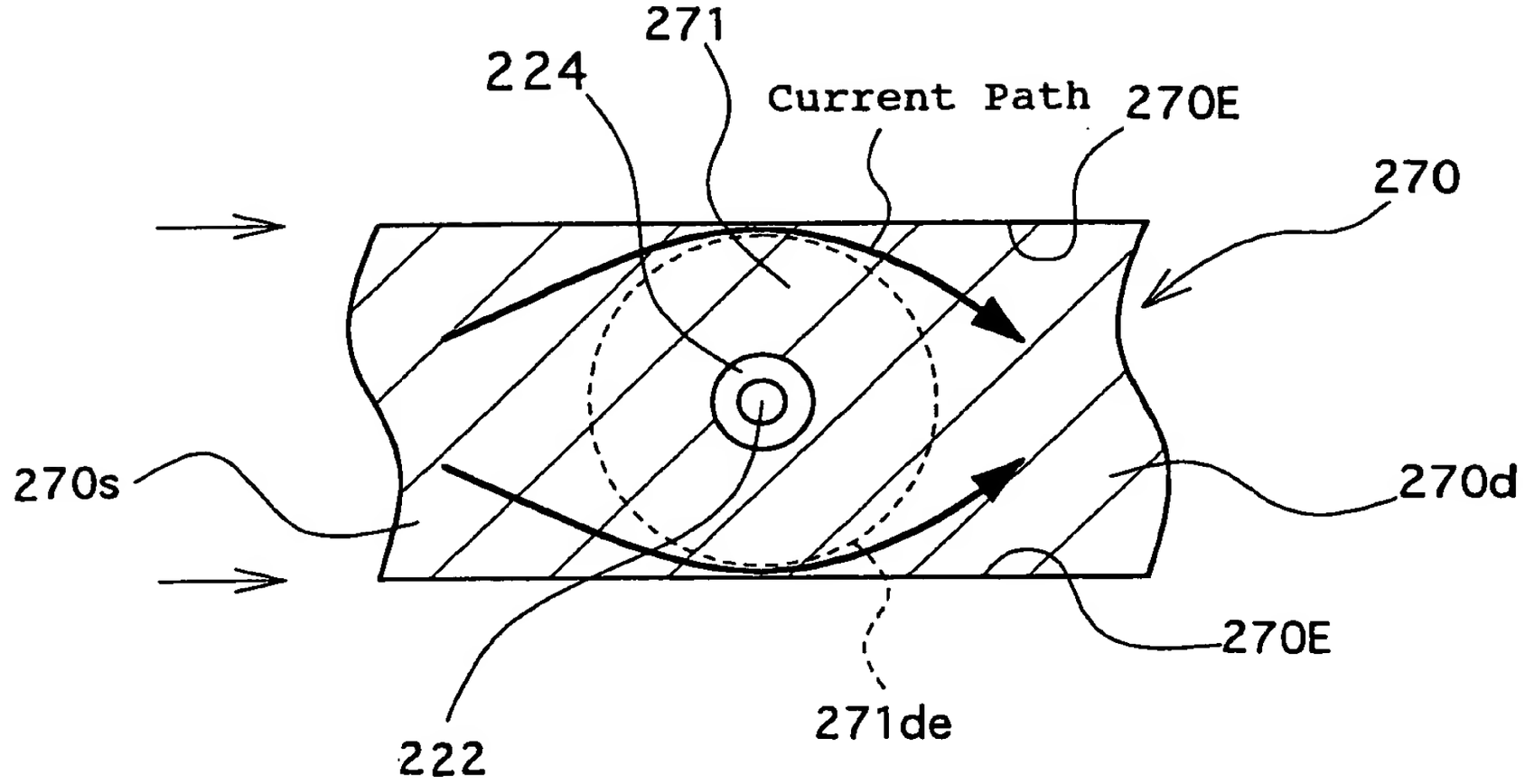


FIG. 30

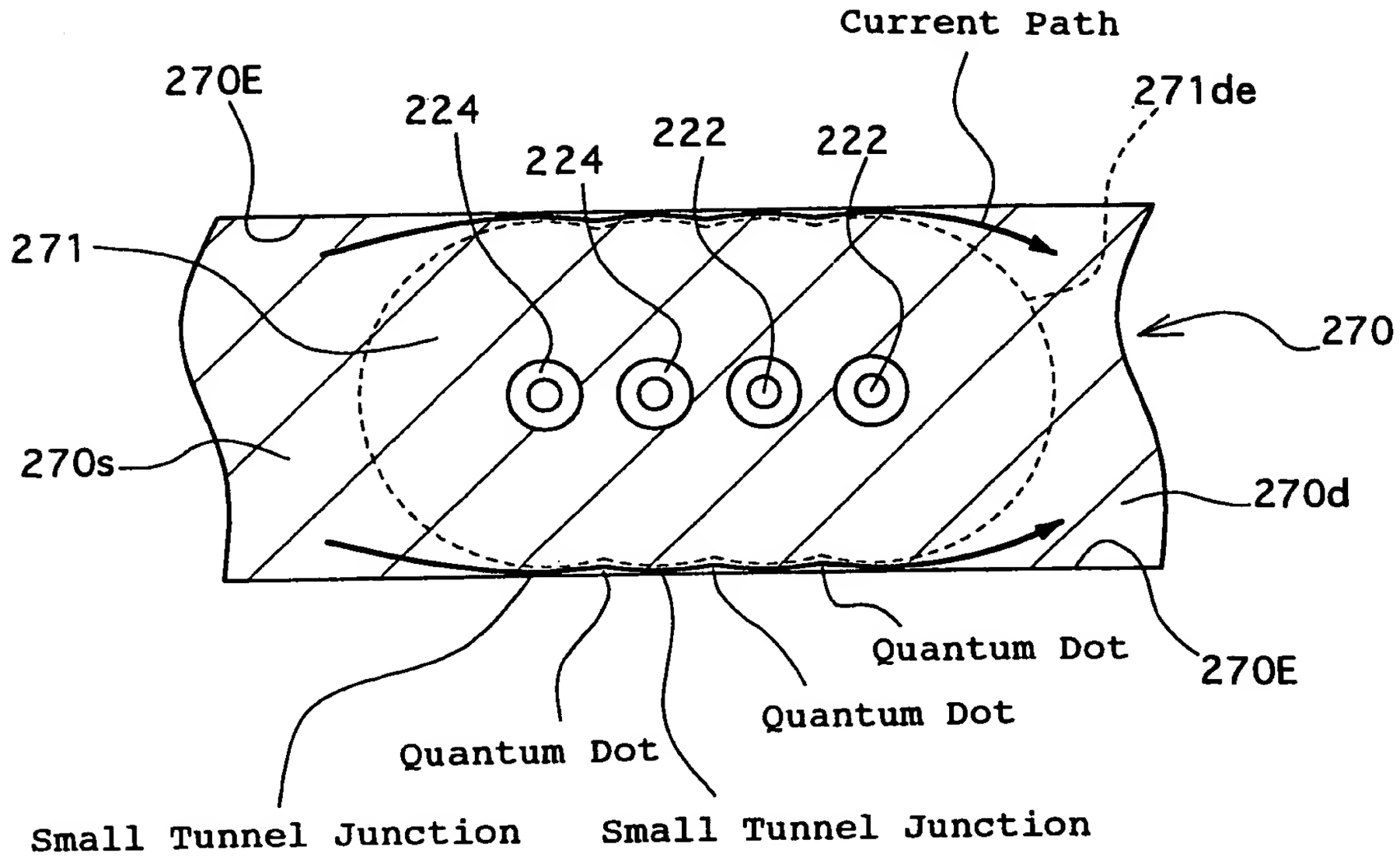

Current Path
270E
224
224
222
222
271de
271
270
270s
270d
Quantum Dot
270E
Quantum Dot
Quantum Dot
Small Tunnel Junction
Small Tunnel Junction

FIG. 31

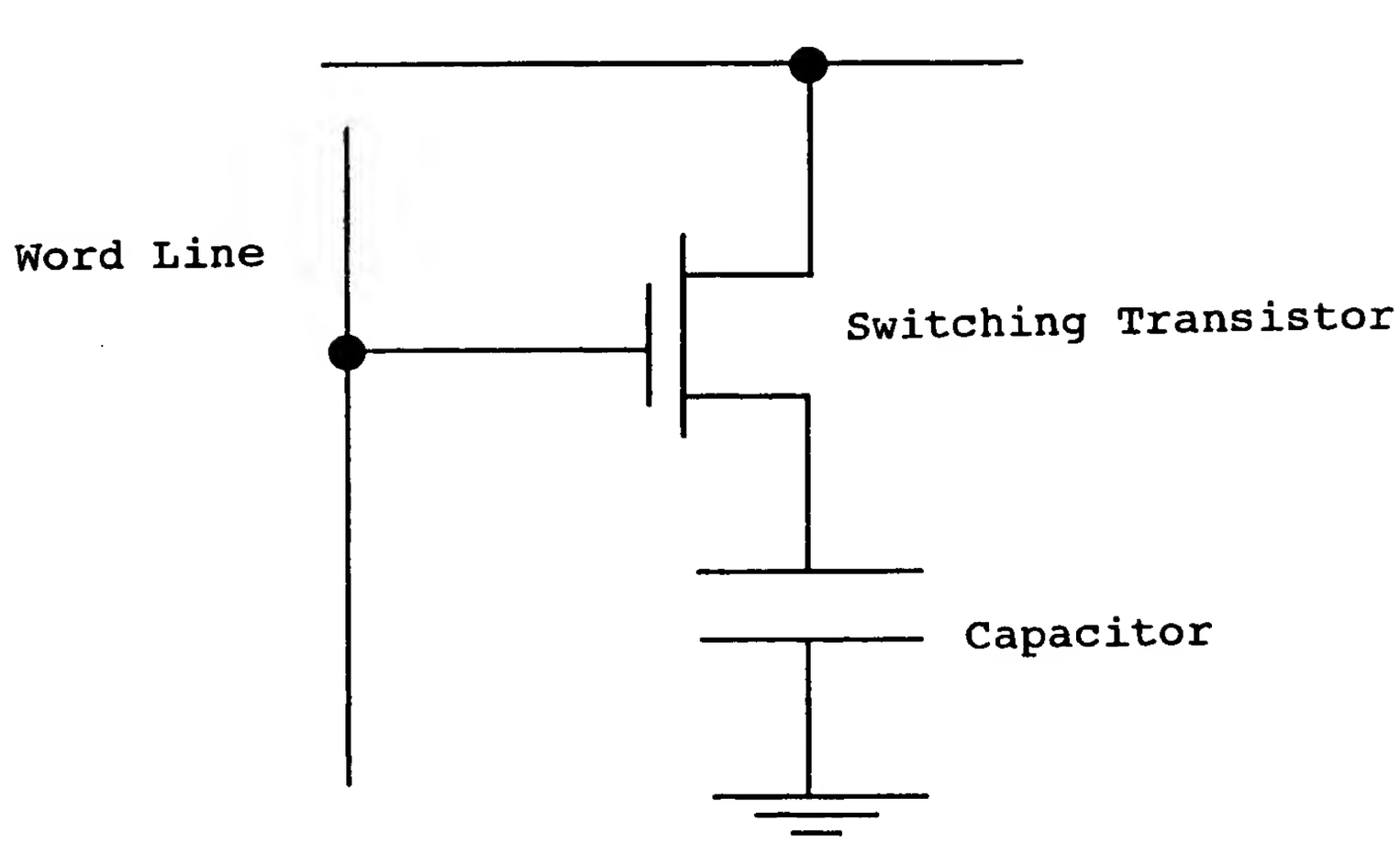


FIG. 32 PRIOR ART

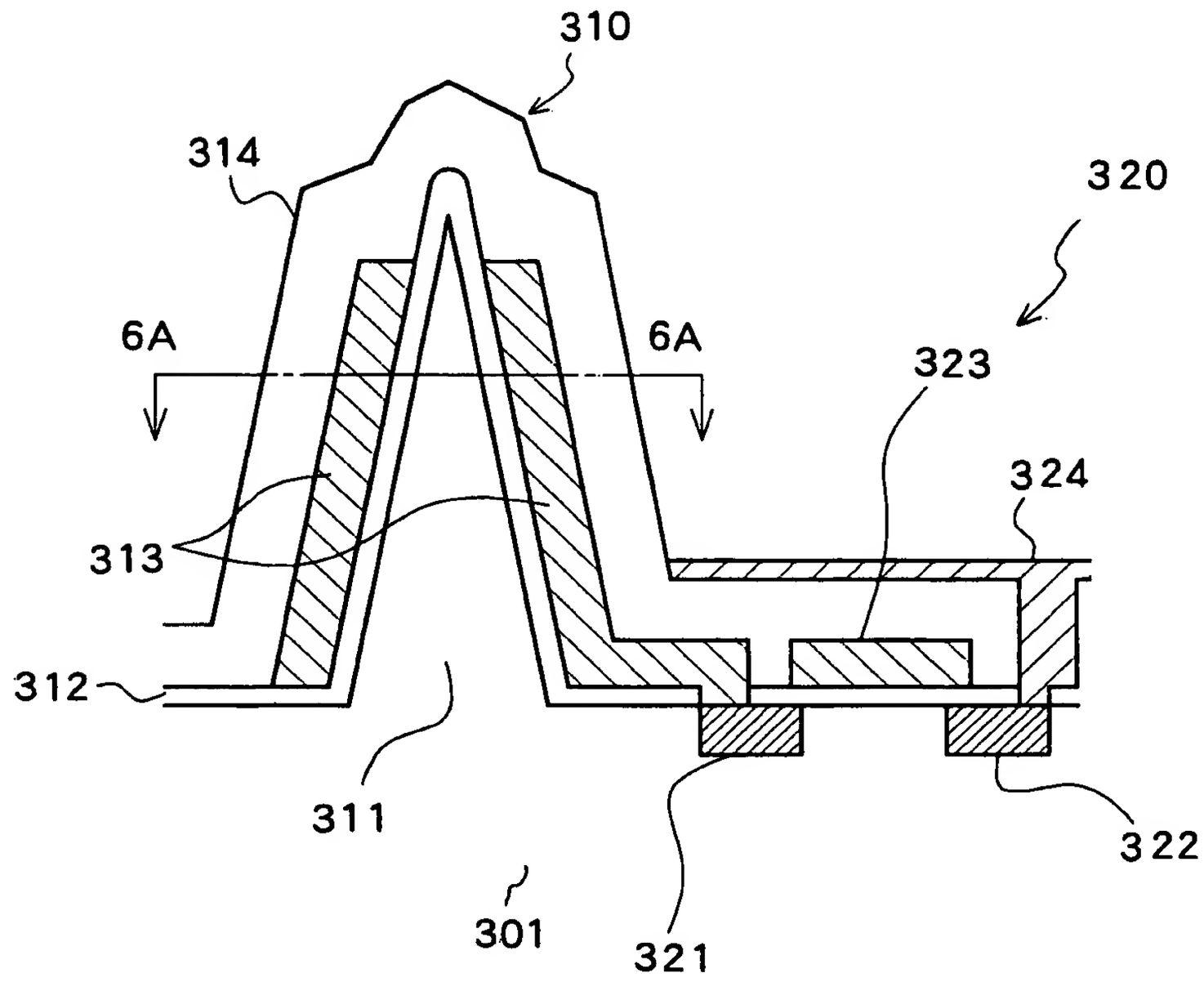


FIG. 33A

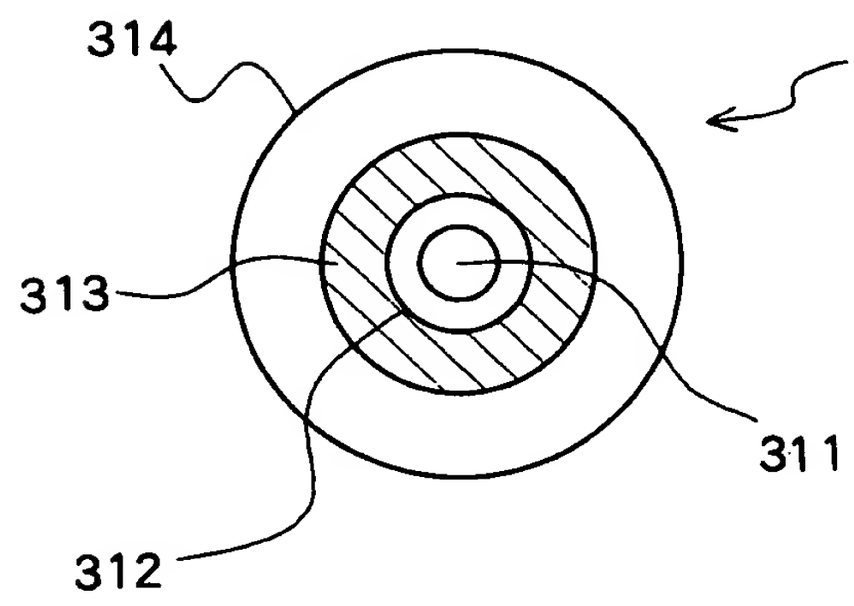


FIG. 33B

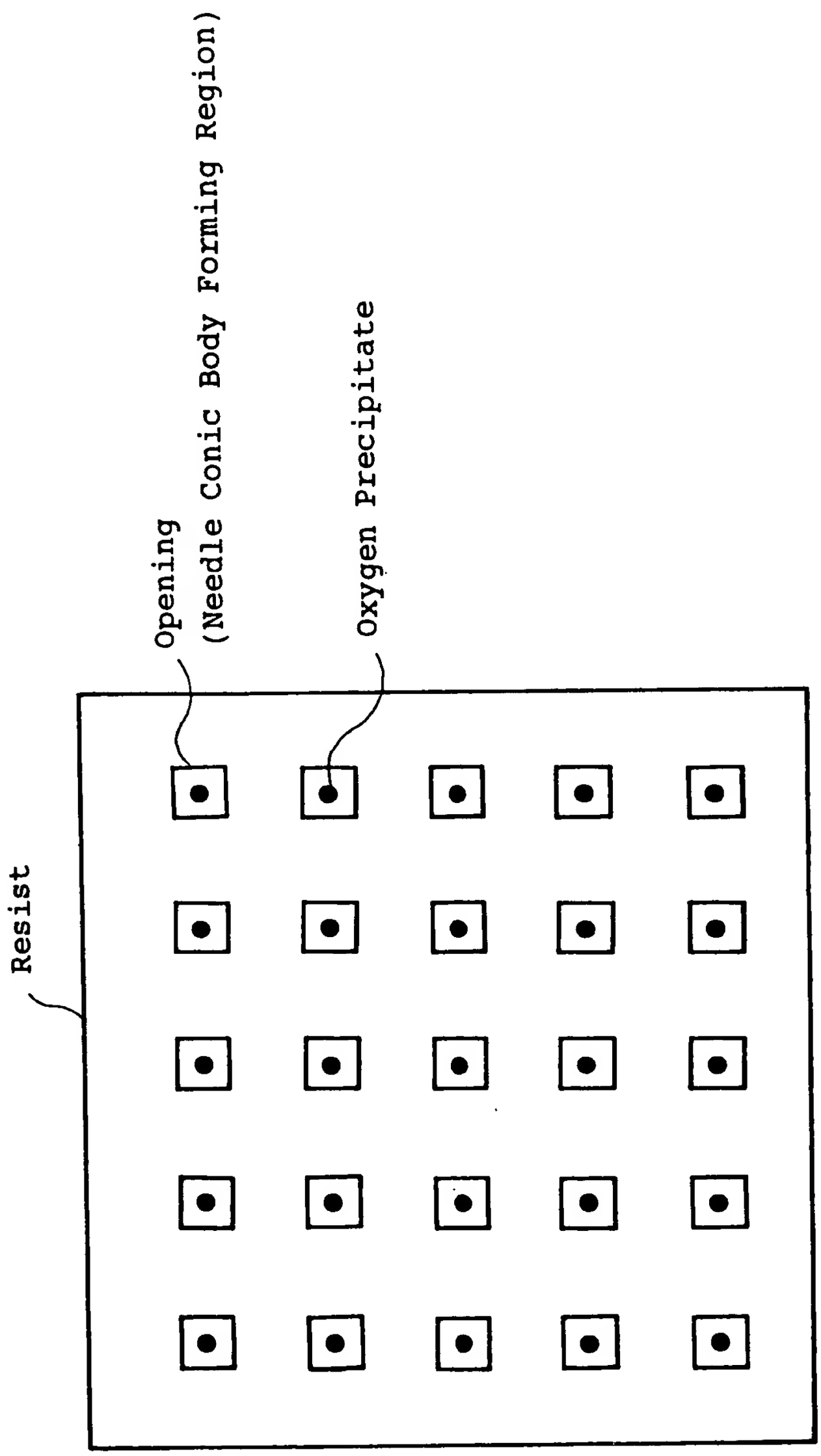

Conic Body Forming Region)
Precipitate
Opening (Needle
Oxygen
Resist

FIG. 34

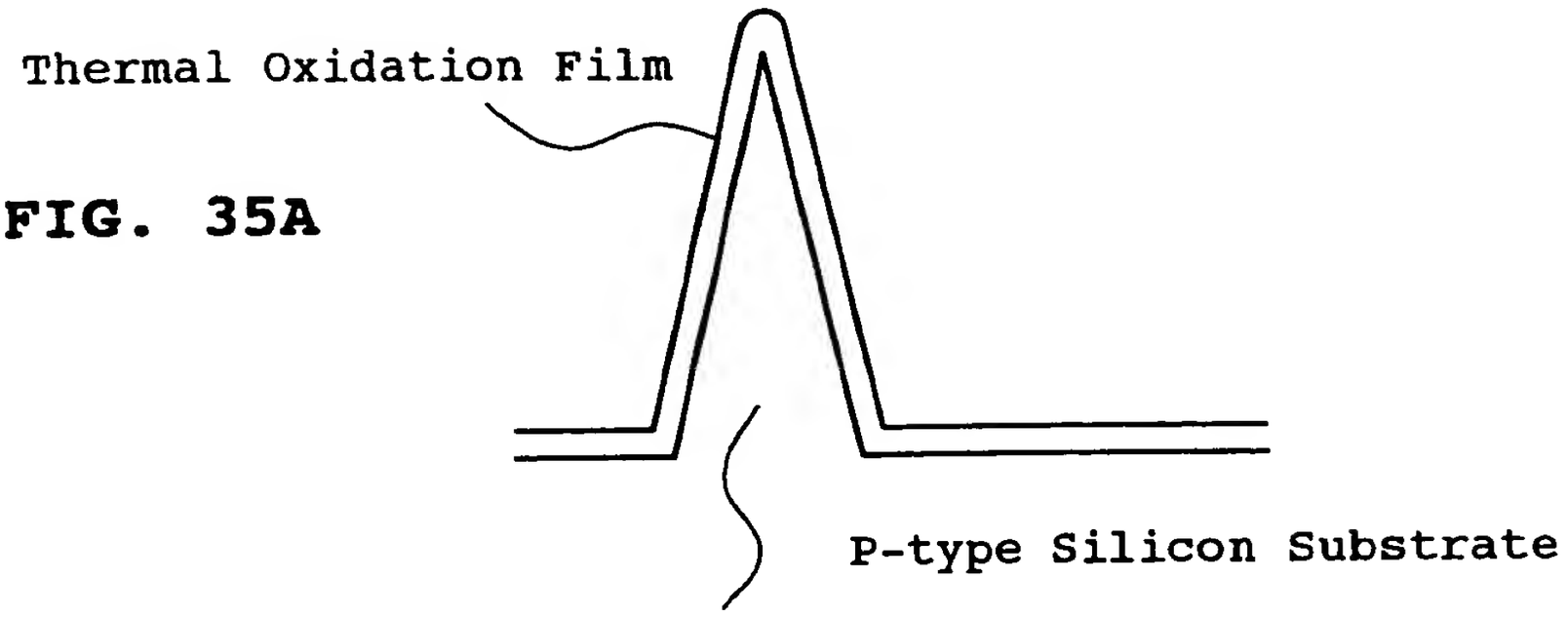


FIG. 35A

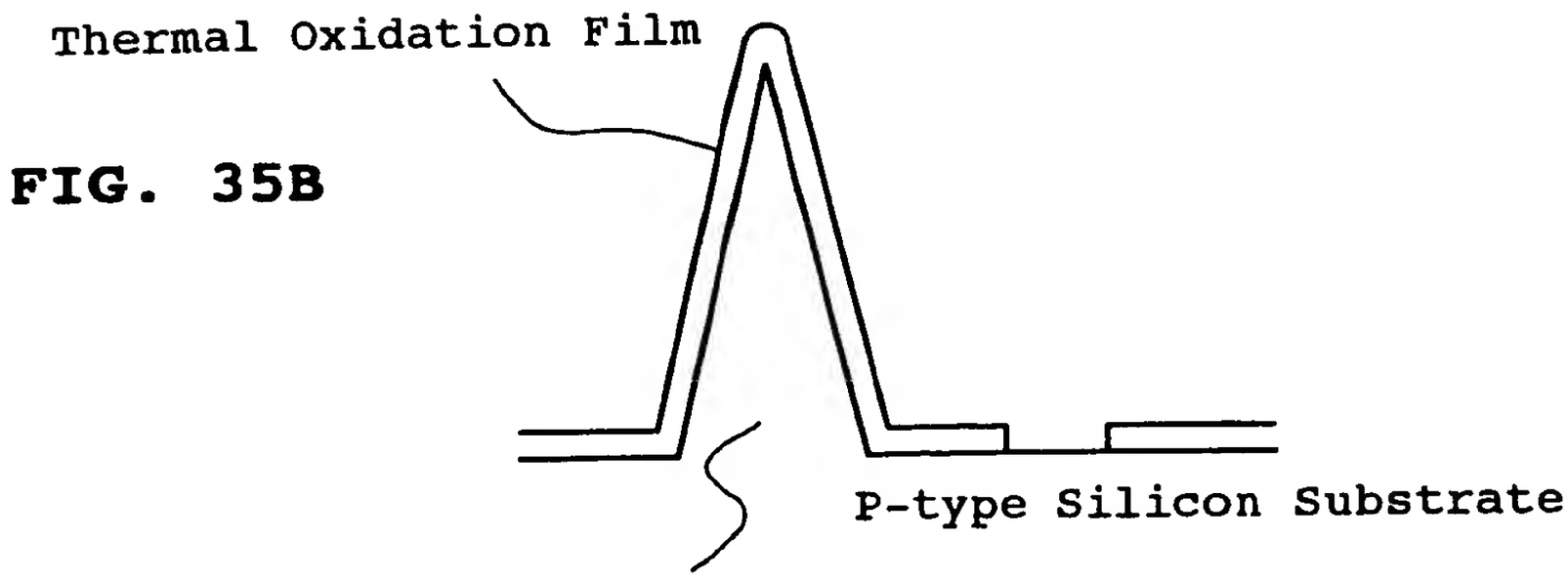


FIG. 35B

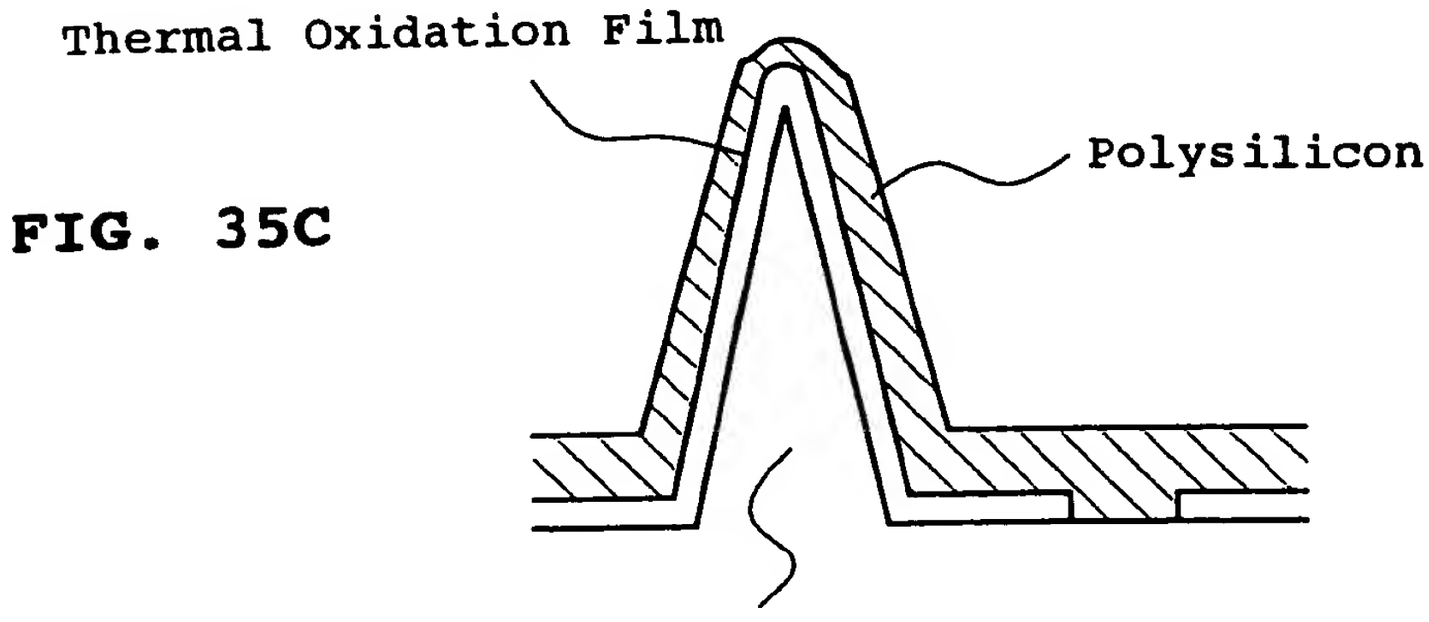


FIG. 35C

FIG. 35D

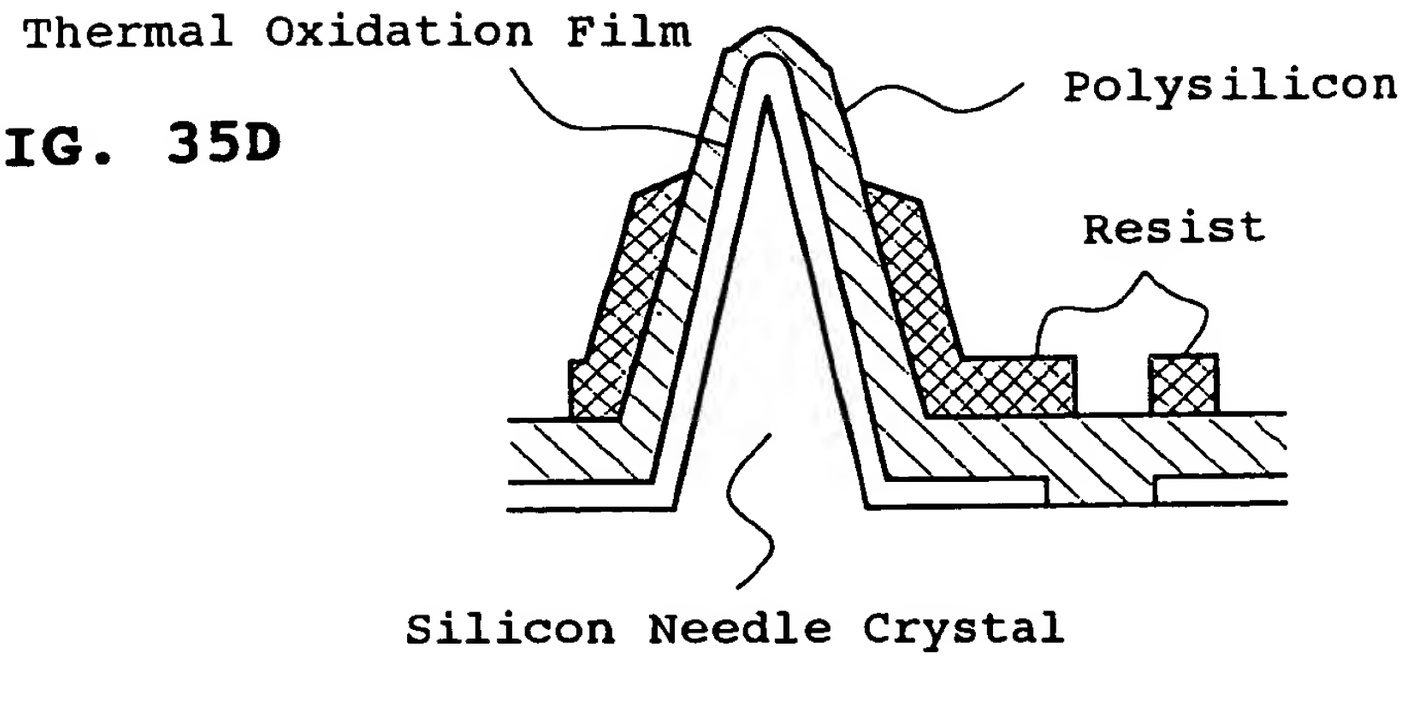


FIG. 35E

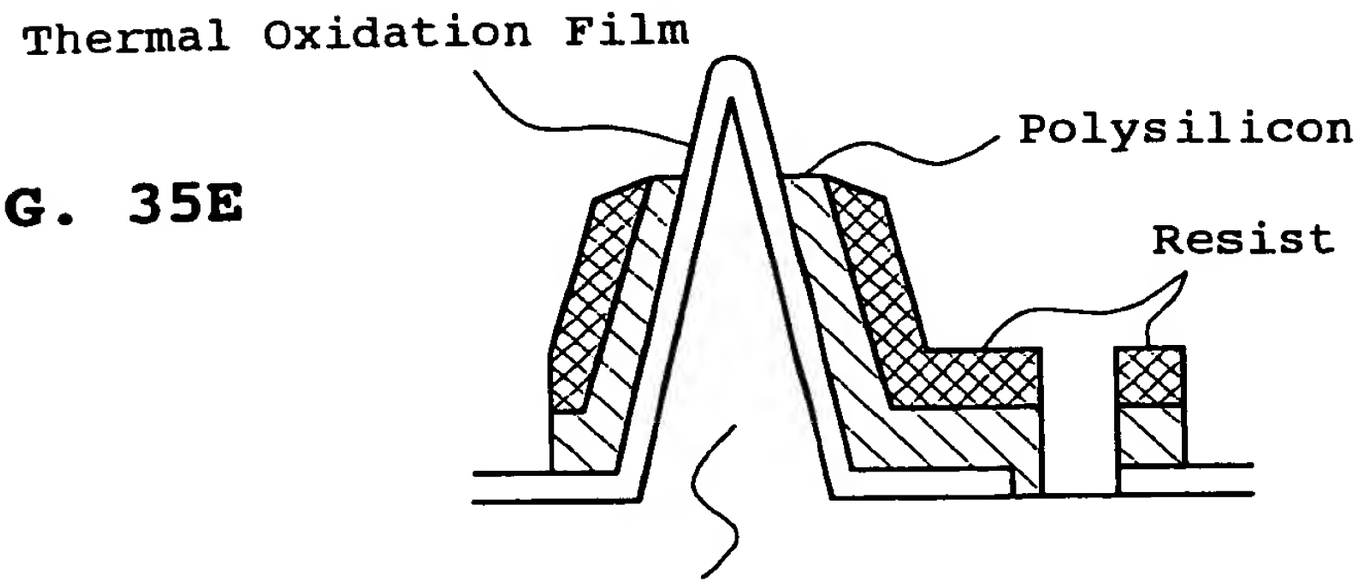
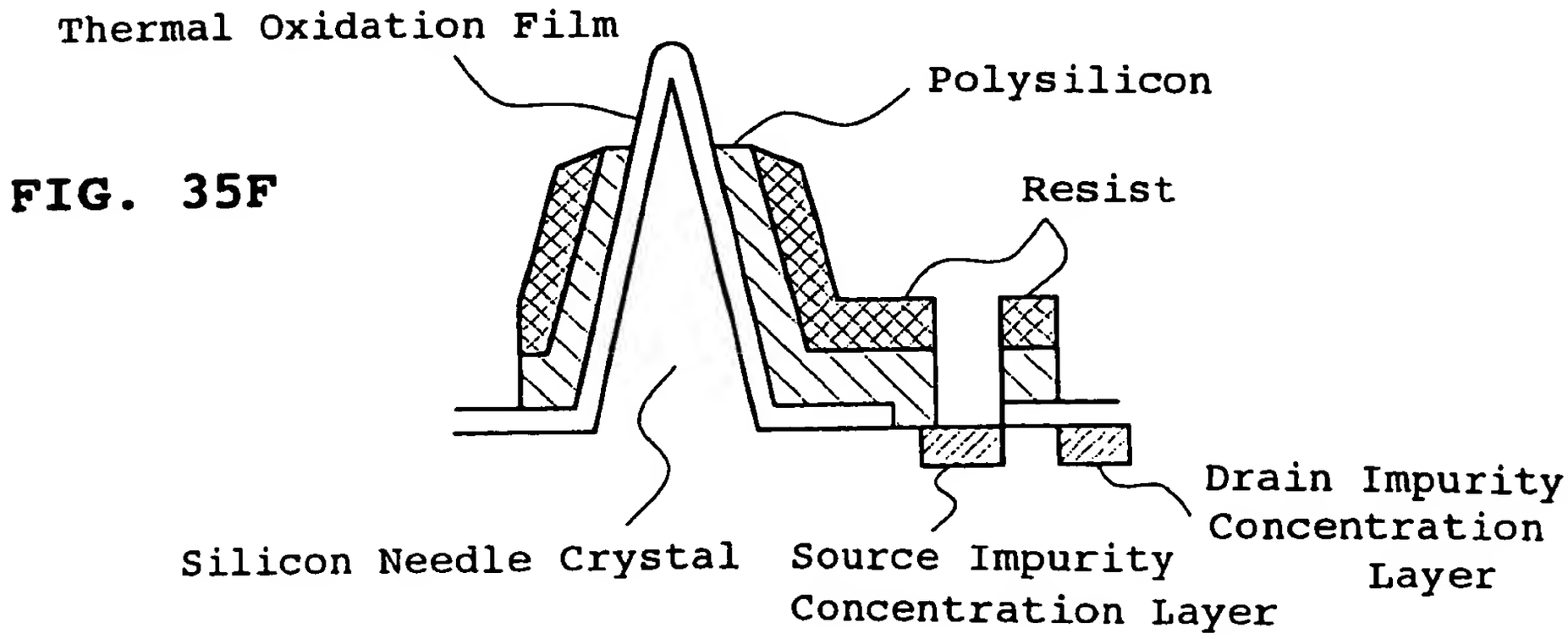


FIG. 35F



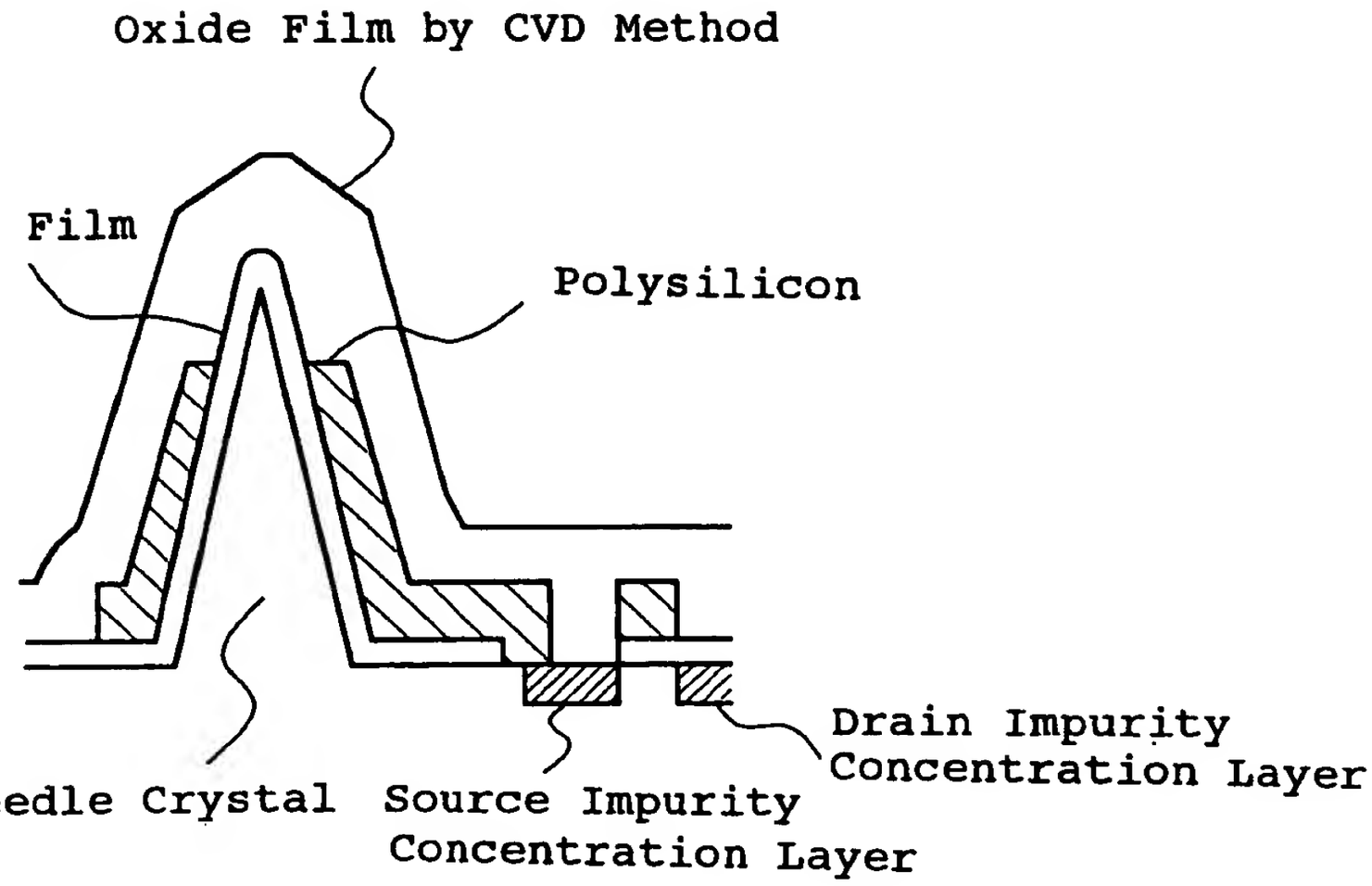


FIG. 35G

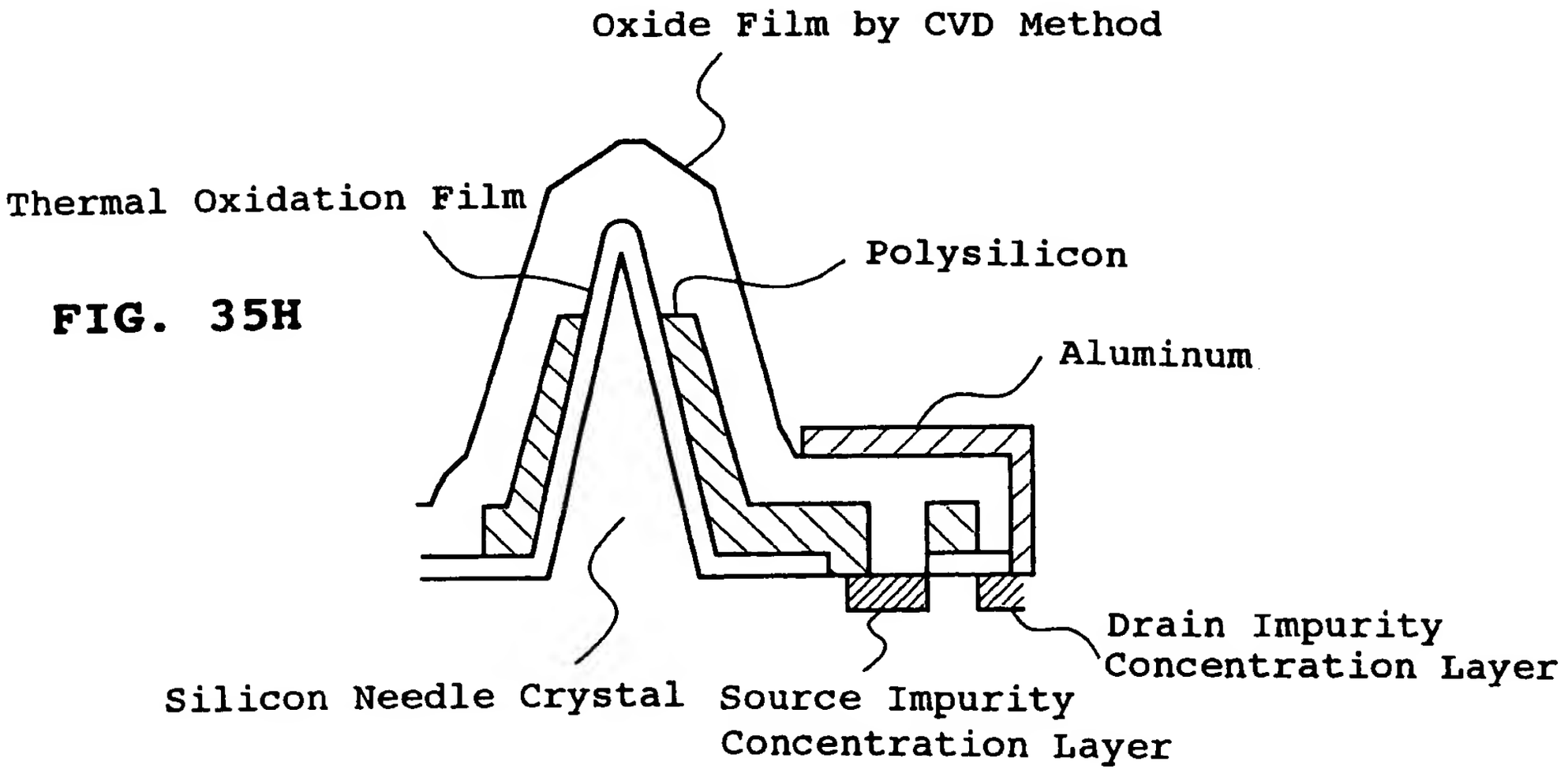


FIG. 35H

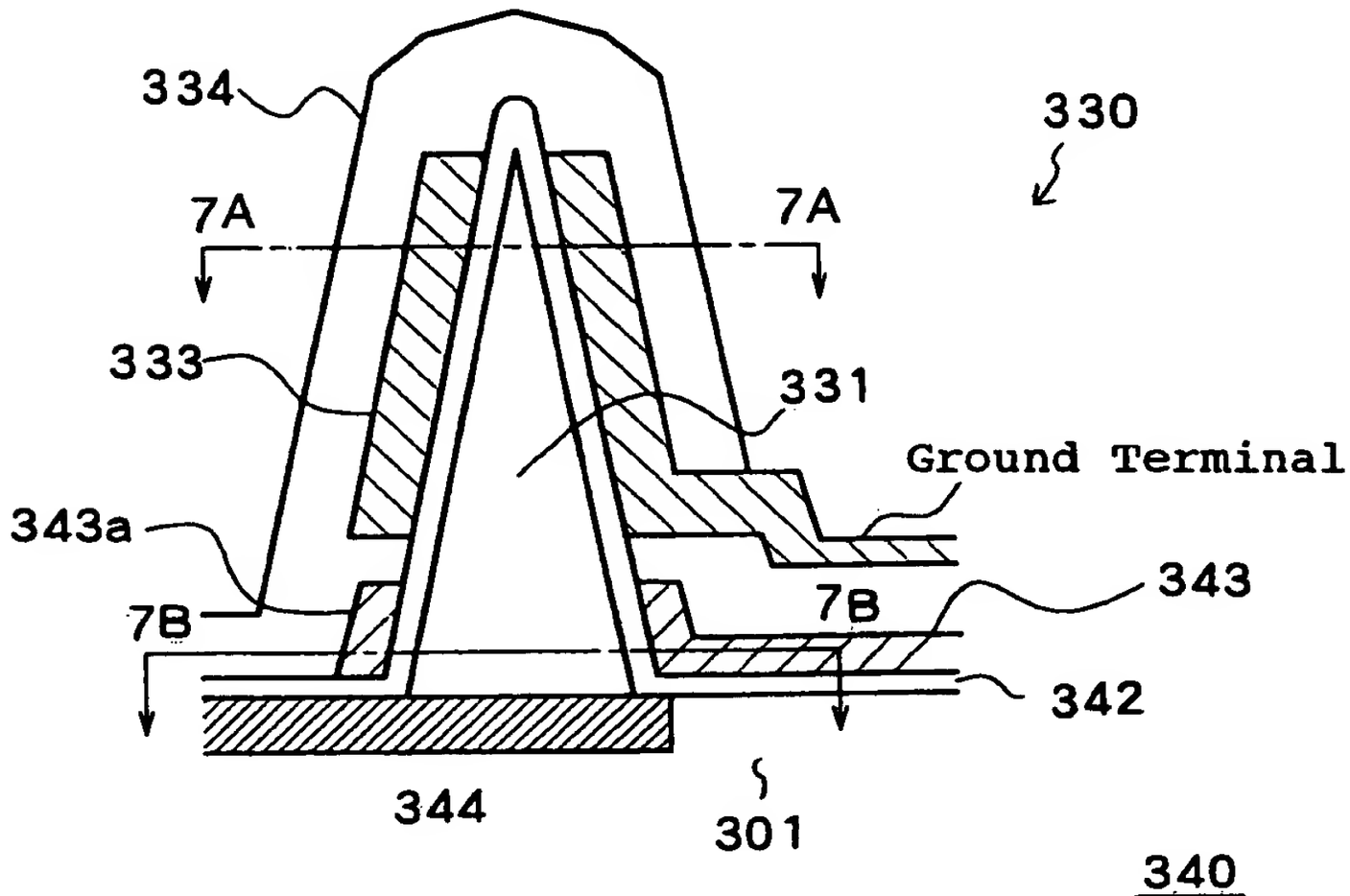


FIG. 36A

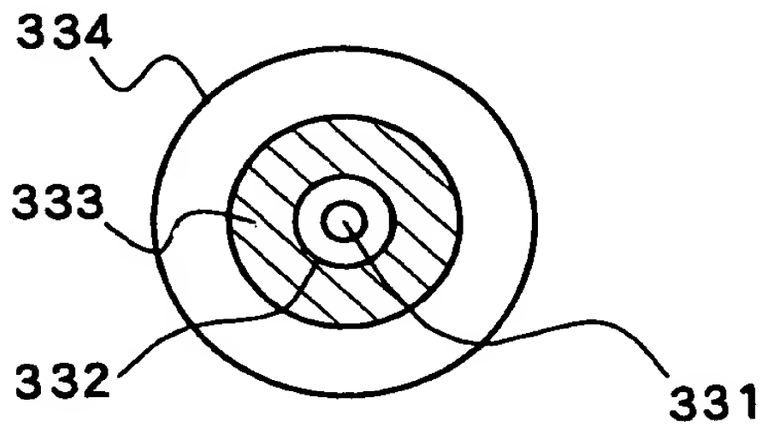


FIG. 36B

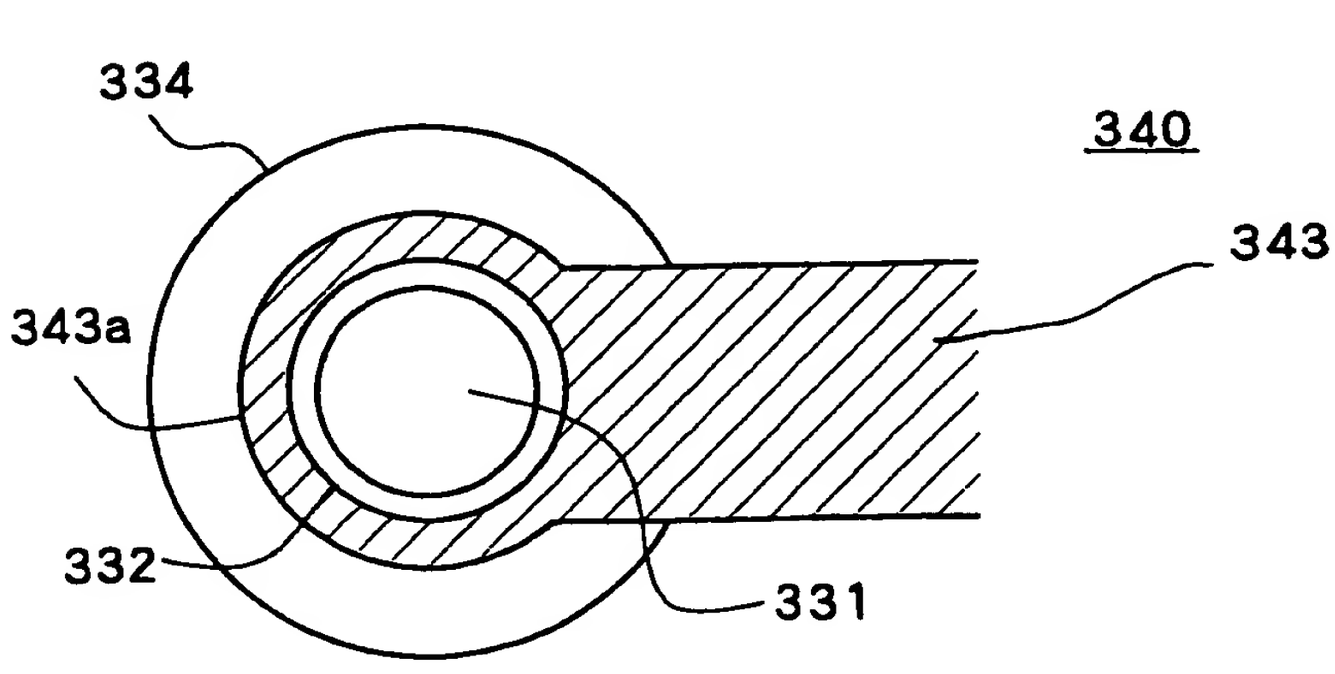


FIG. 36C

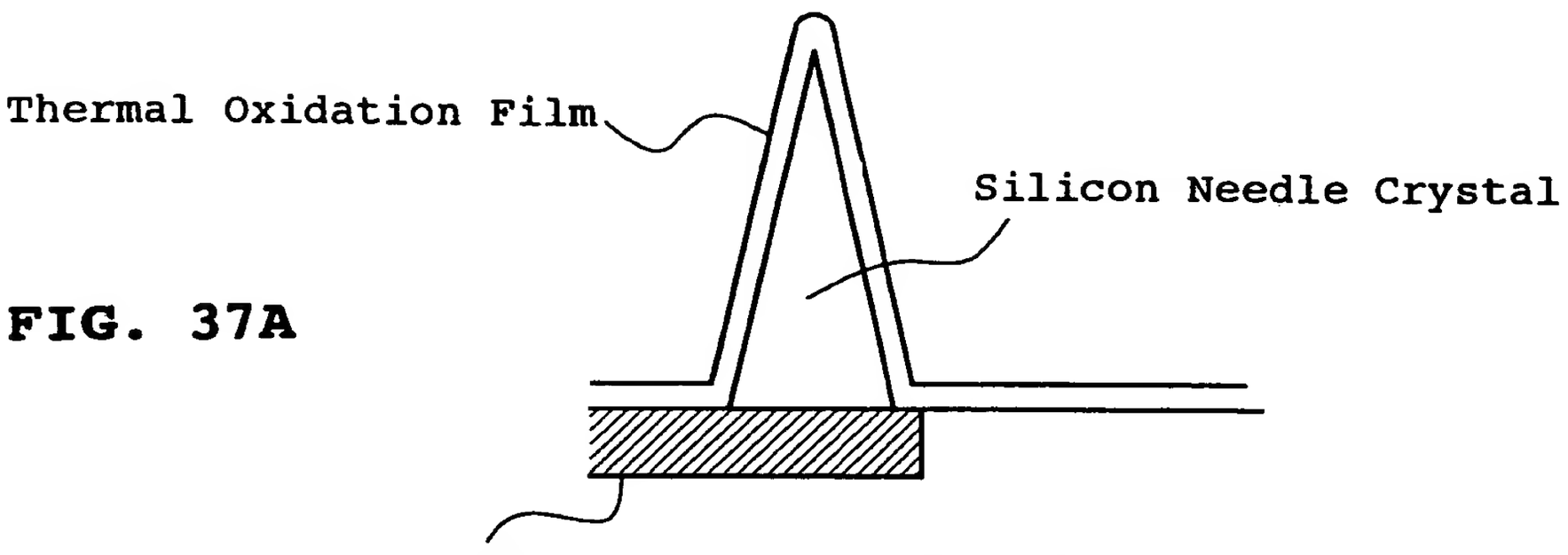


FIG. 37A

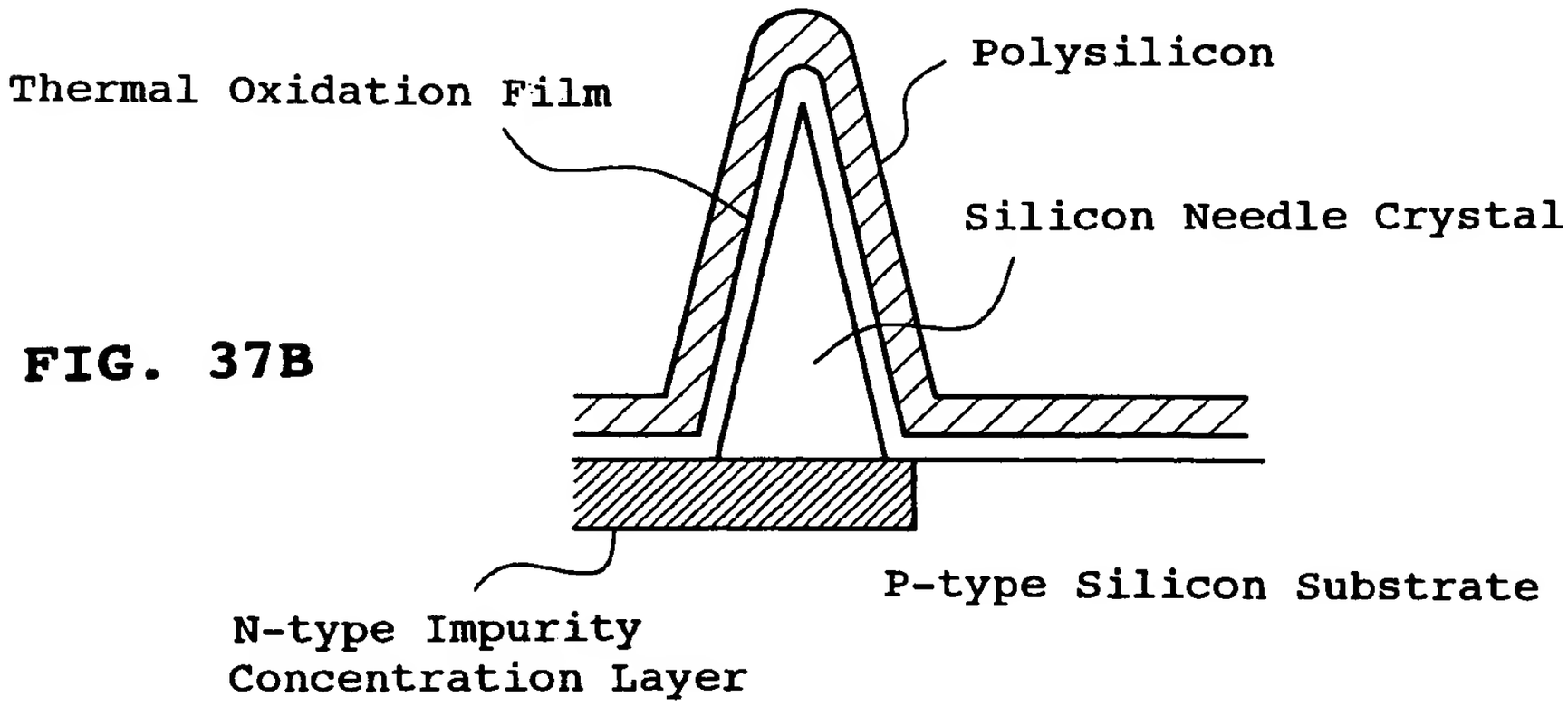


FIG. 37B

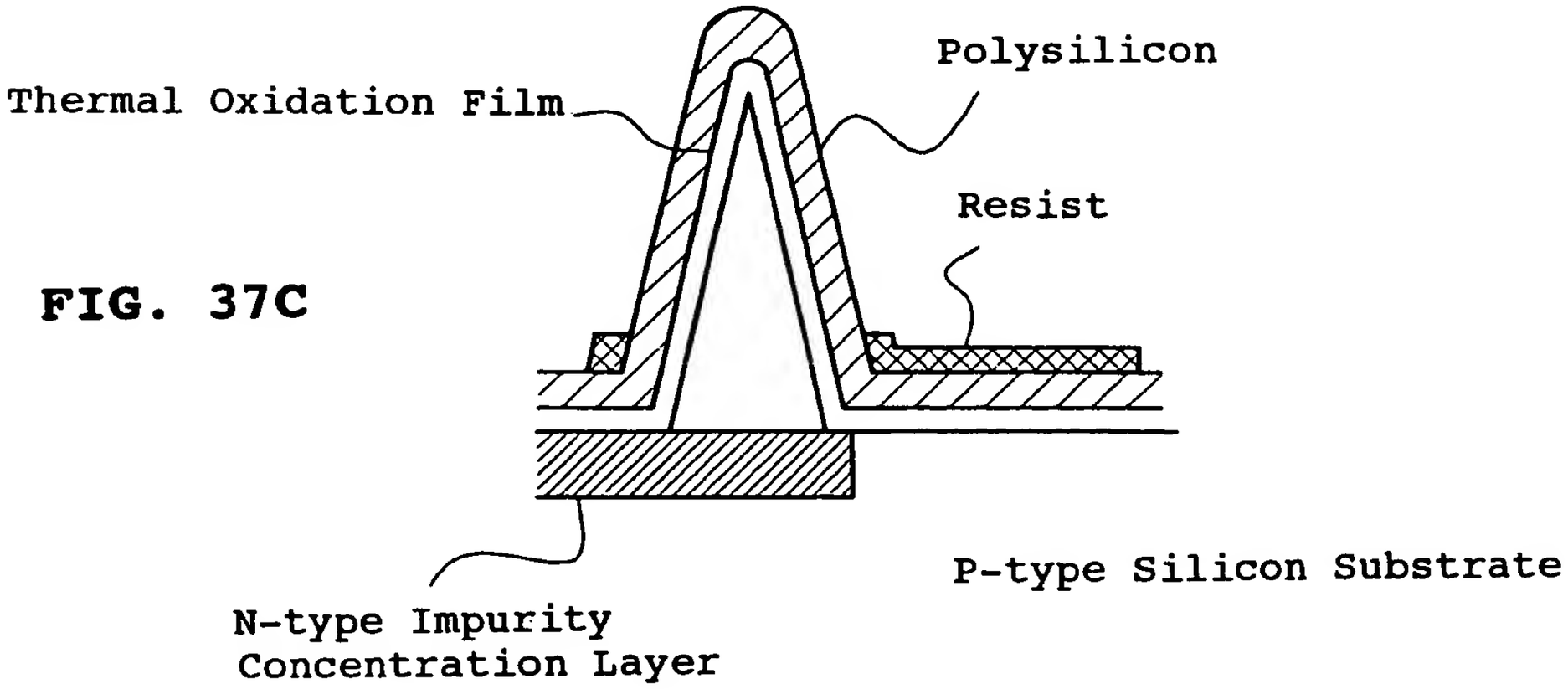


FIG. 37C

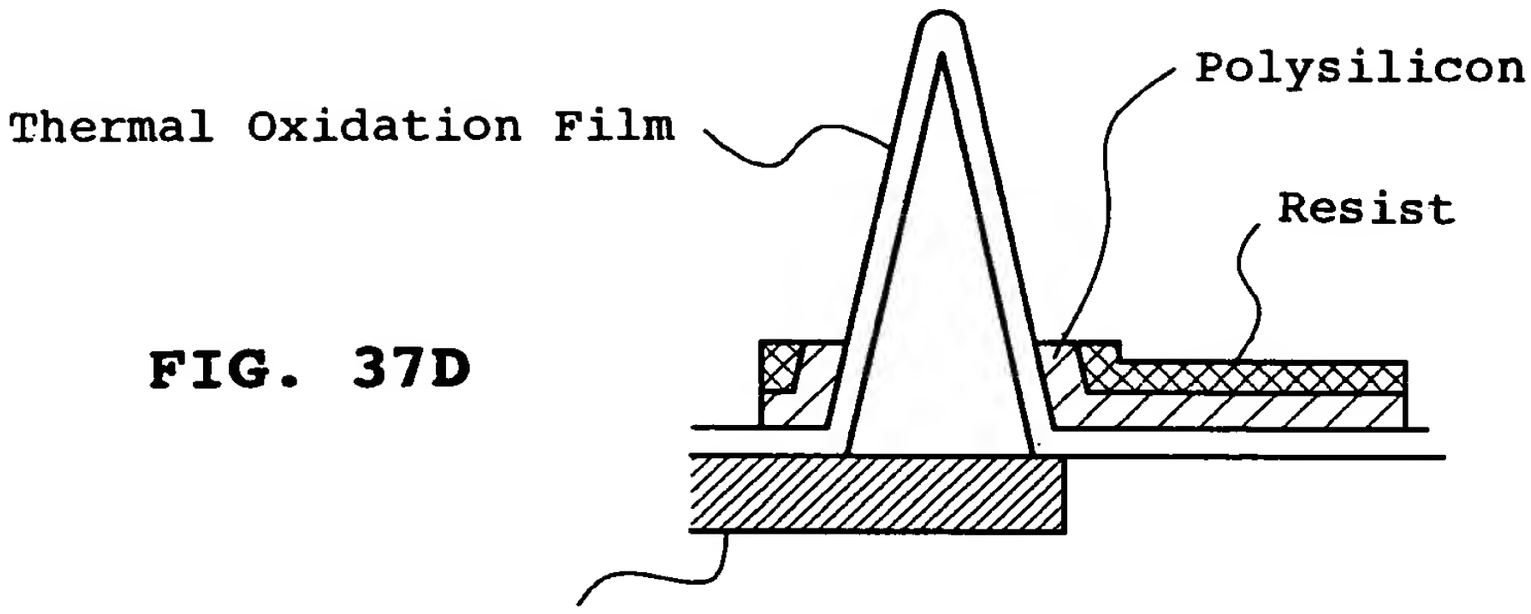


FIG. 37D

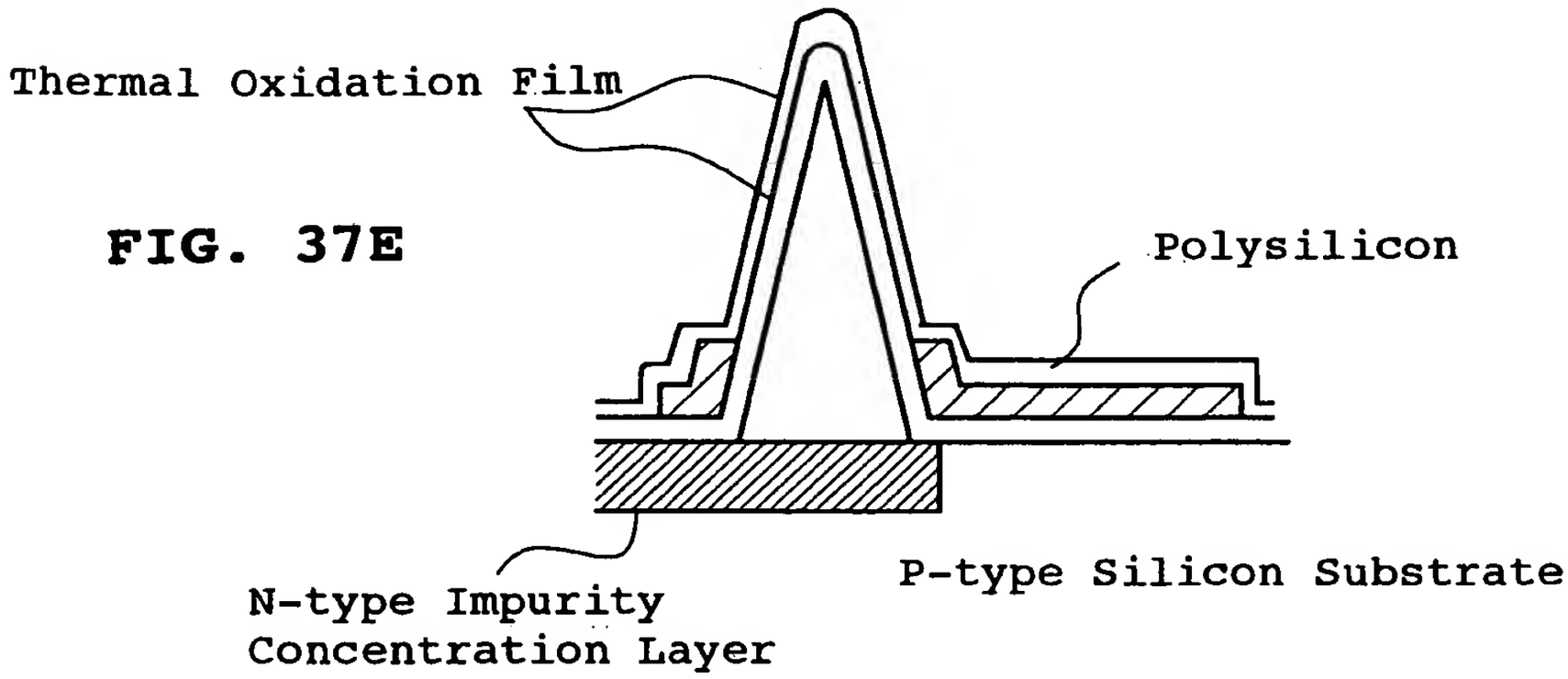


FIG. 37E

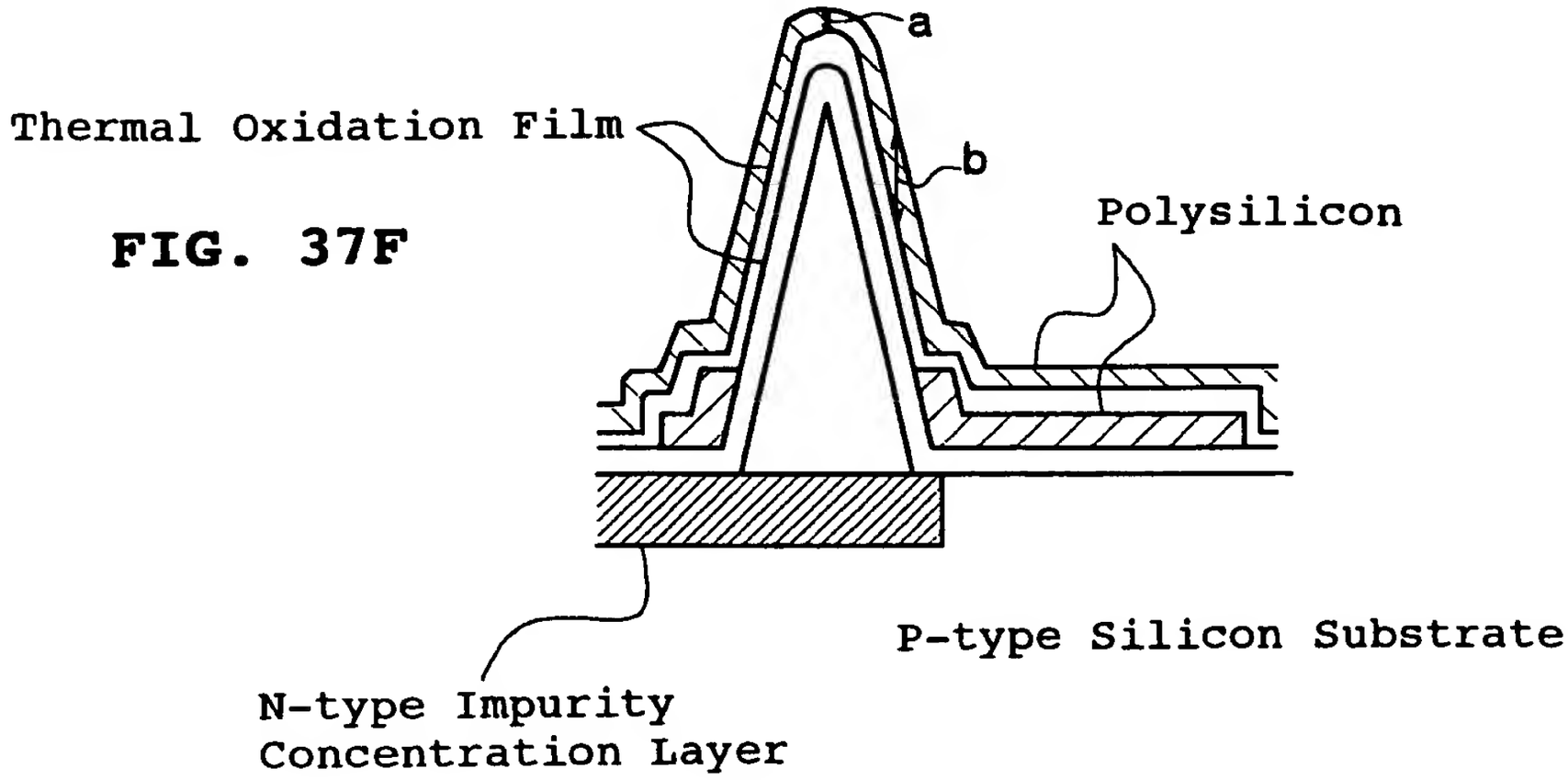


FIG. 37F

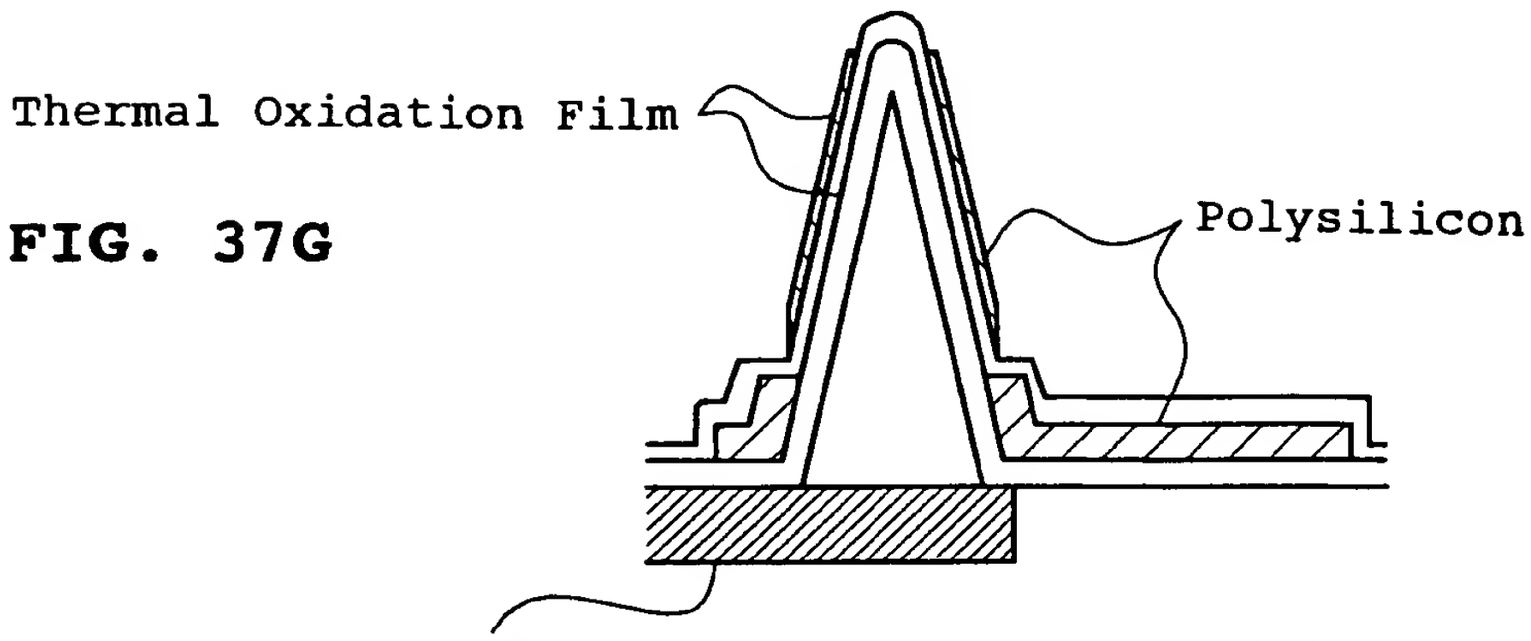


FIG. 37G

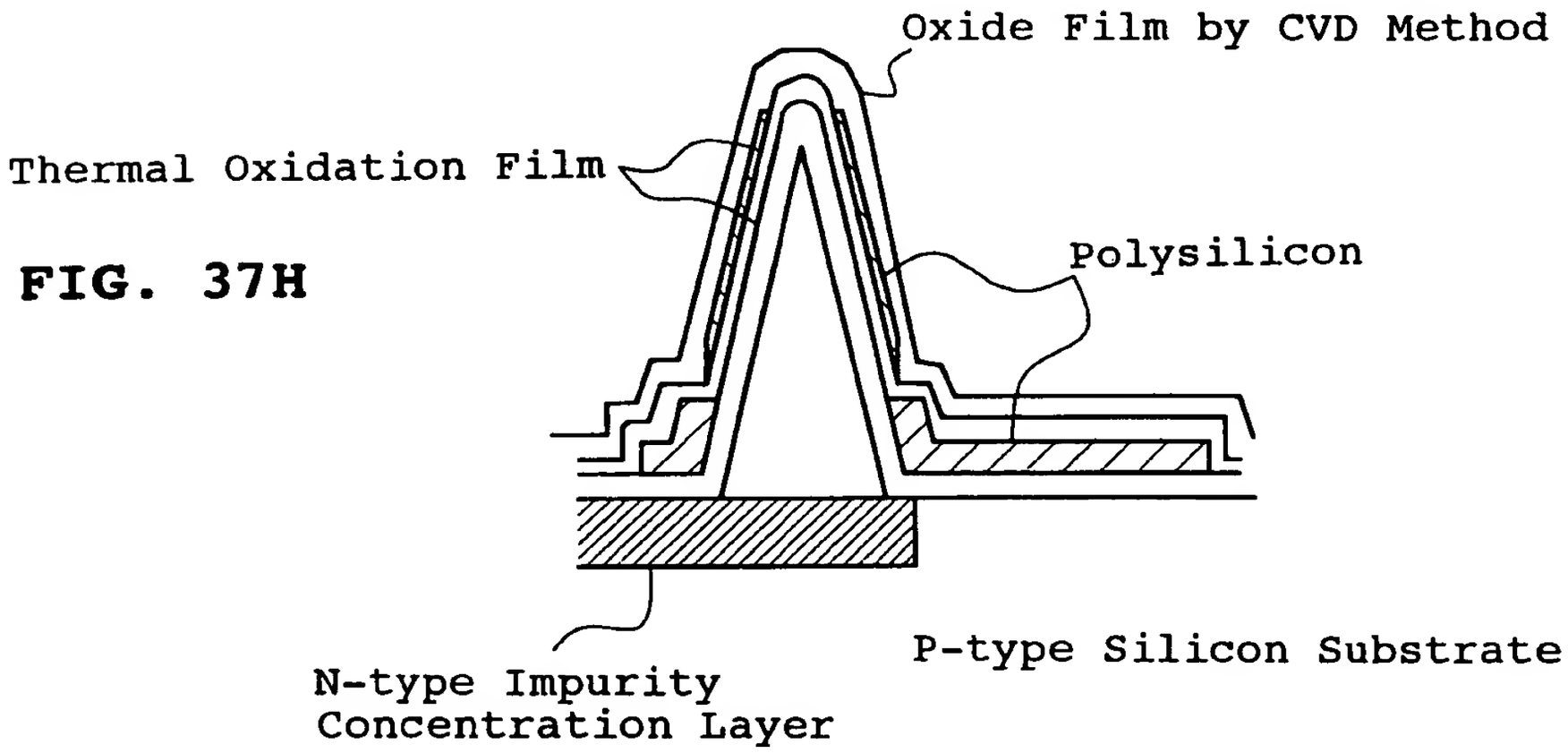


FIG. 37H

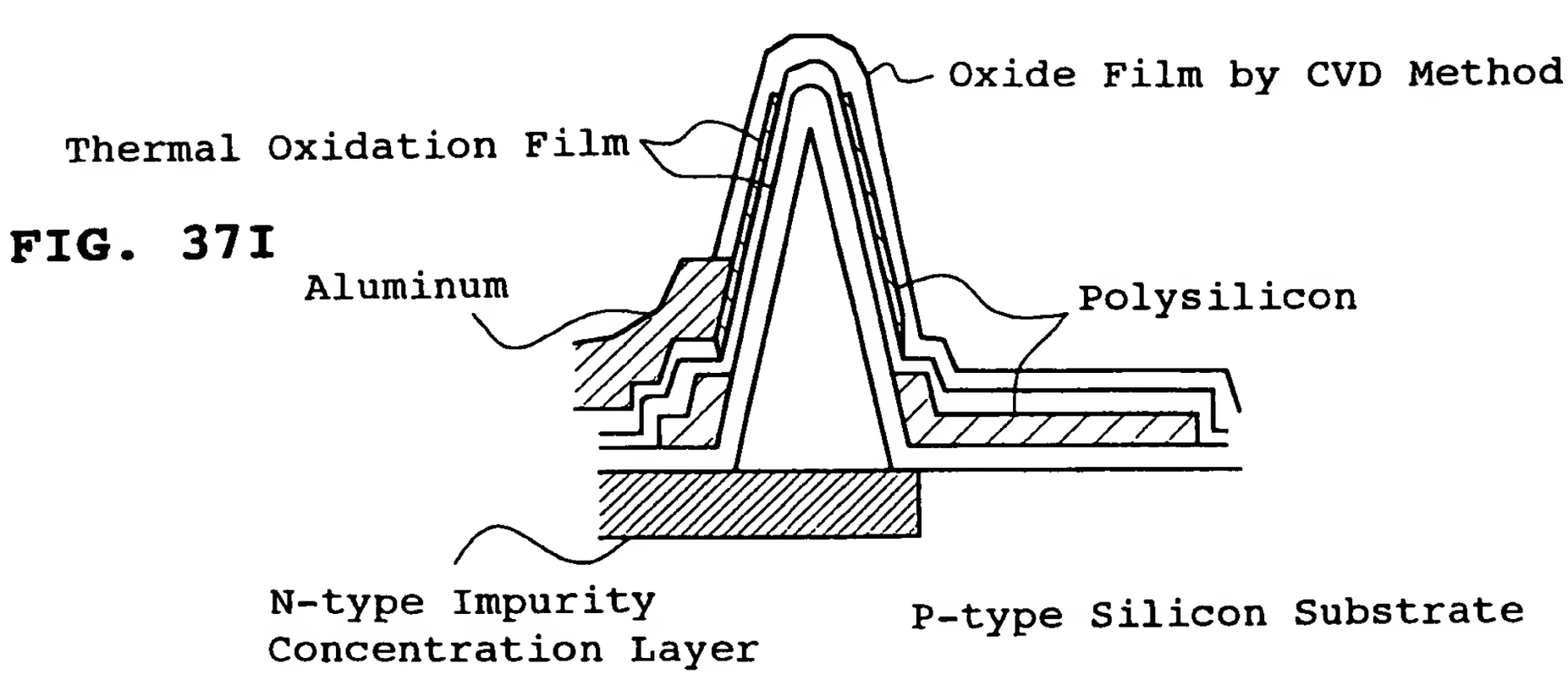


FIG. 37I

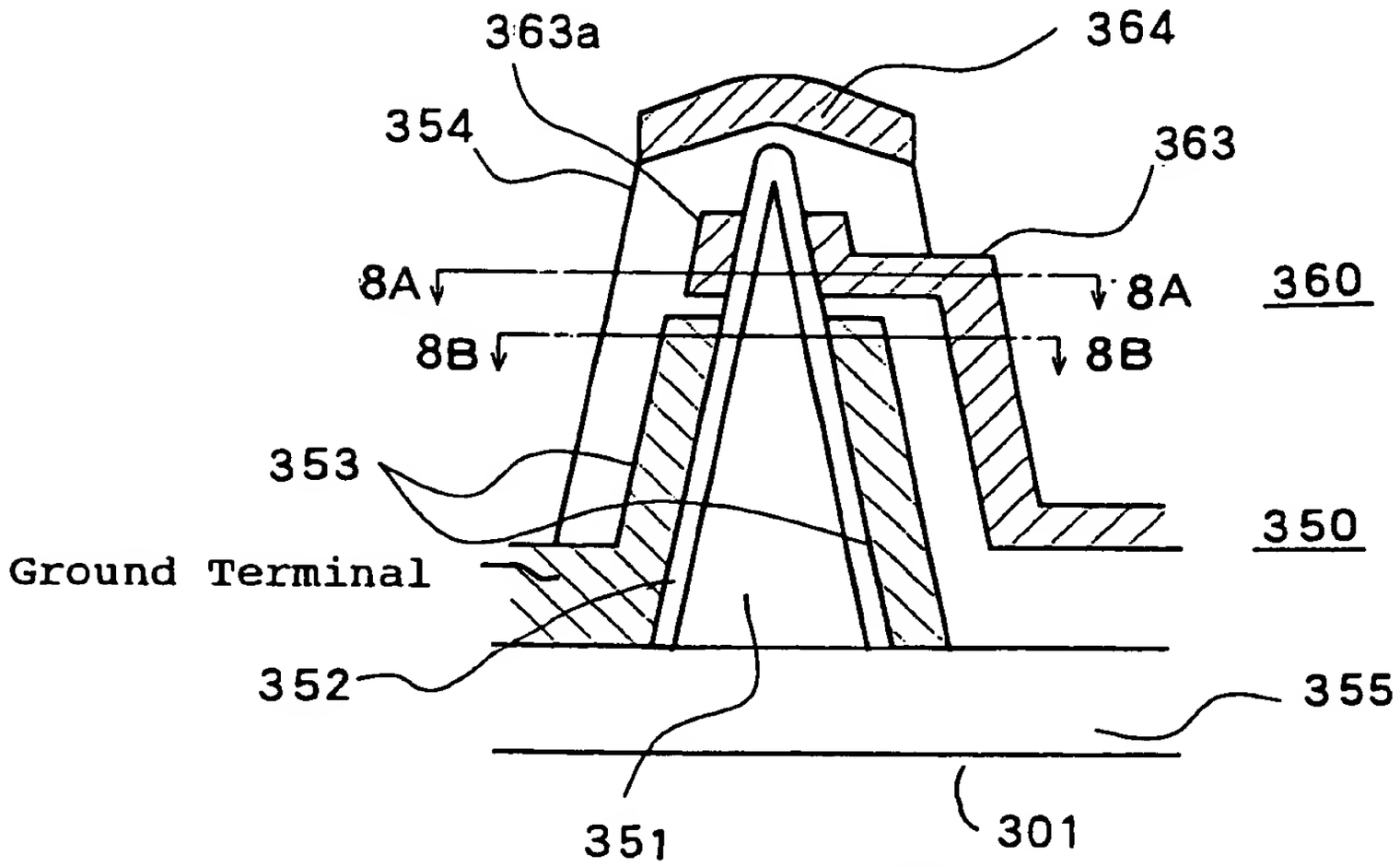


FIG. 38A

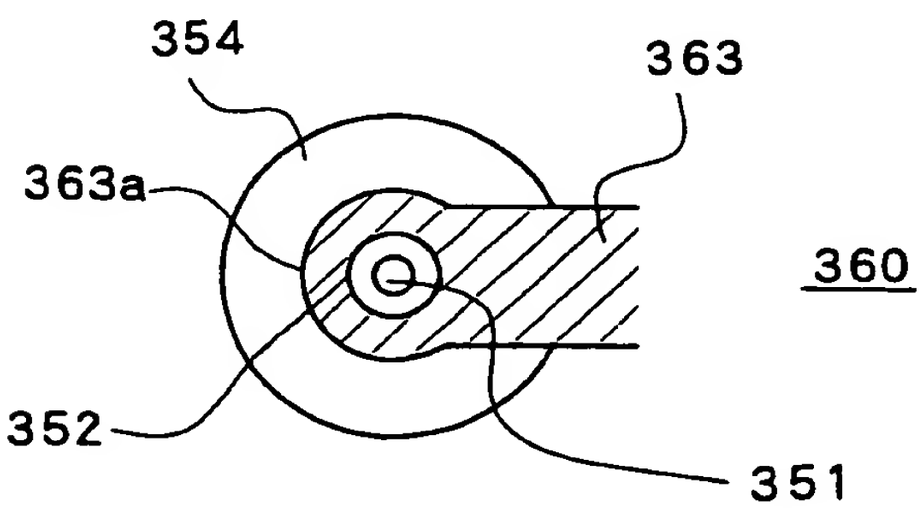


FIG. 38B

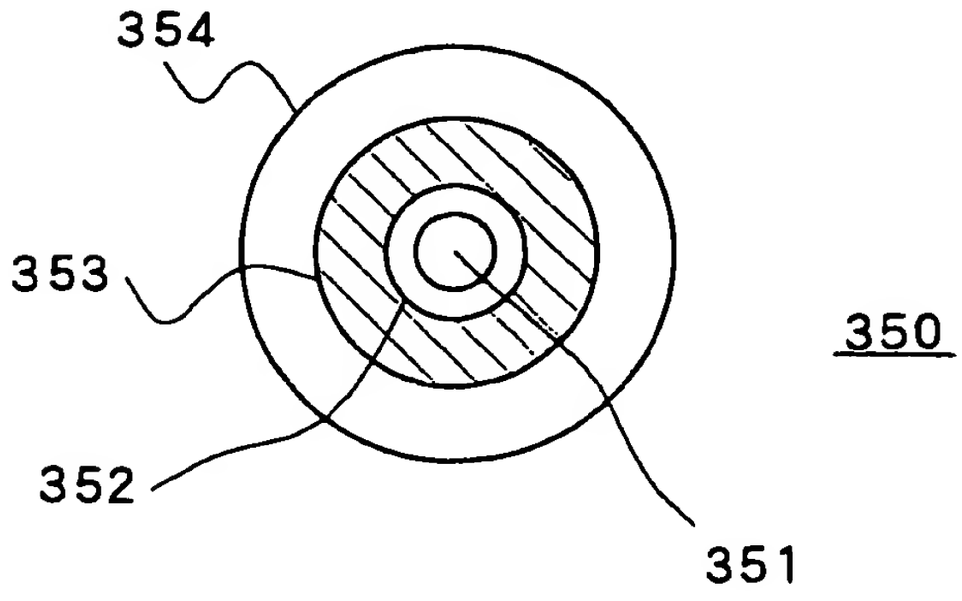


FIG. 38C

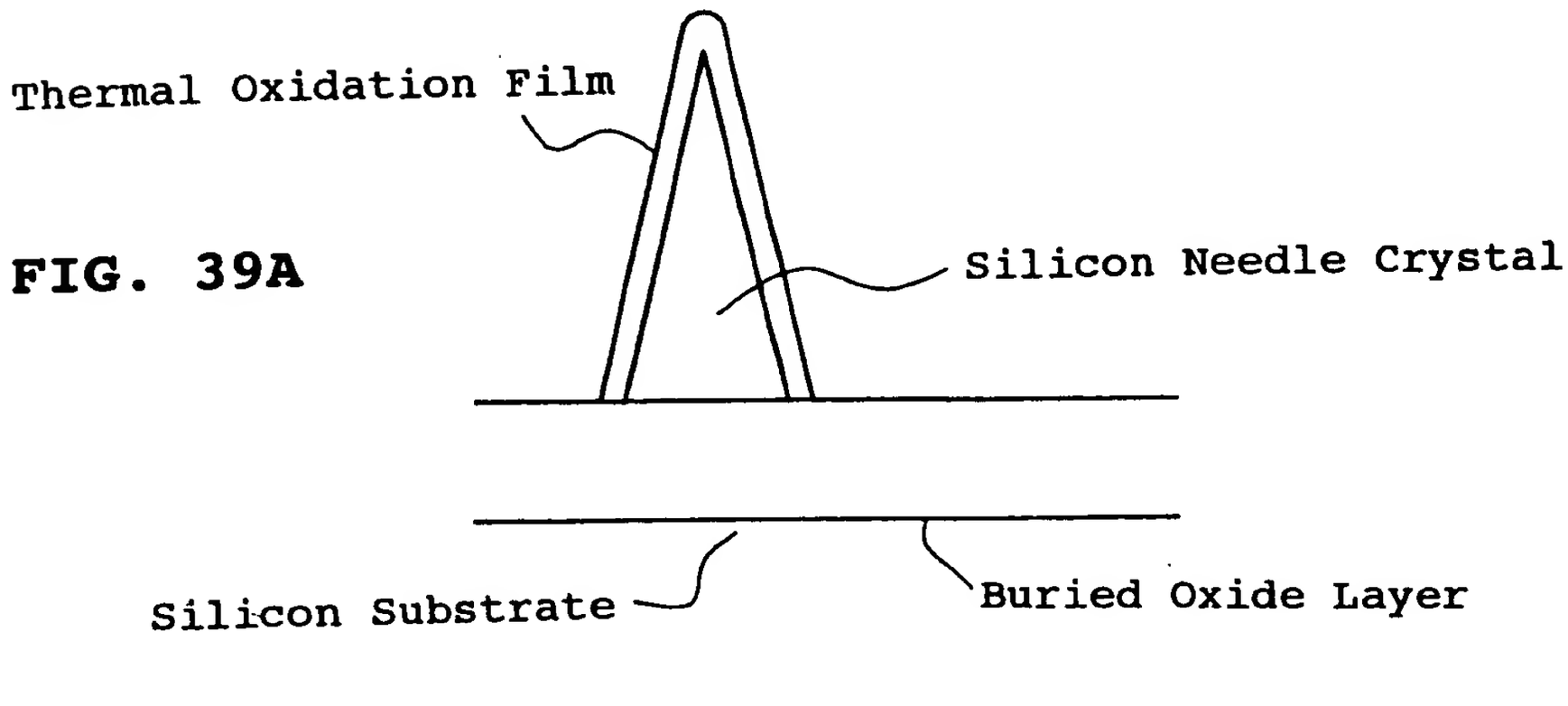


FIG. 39A

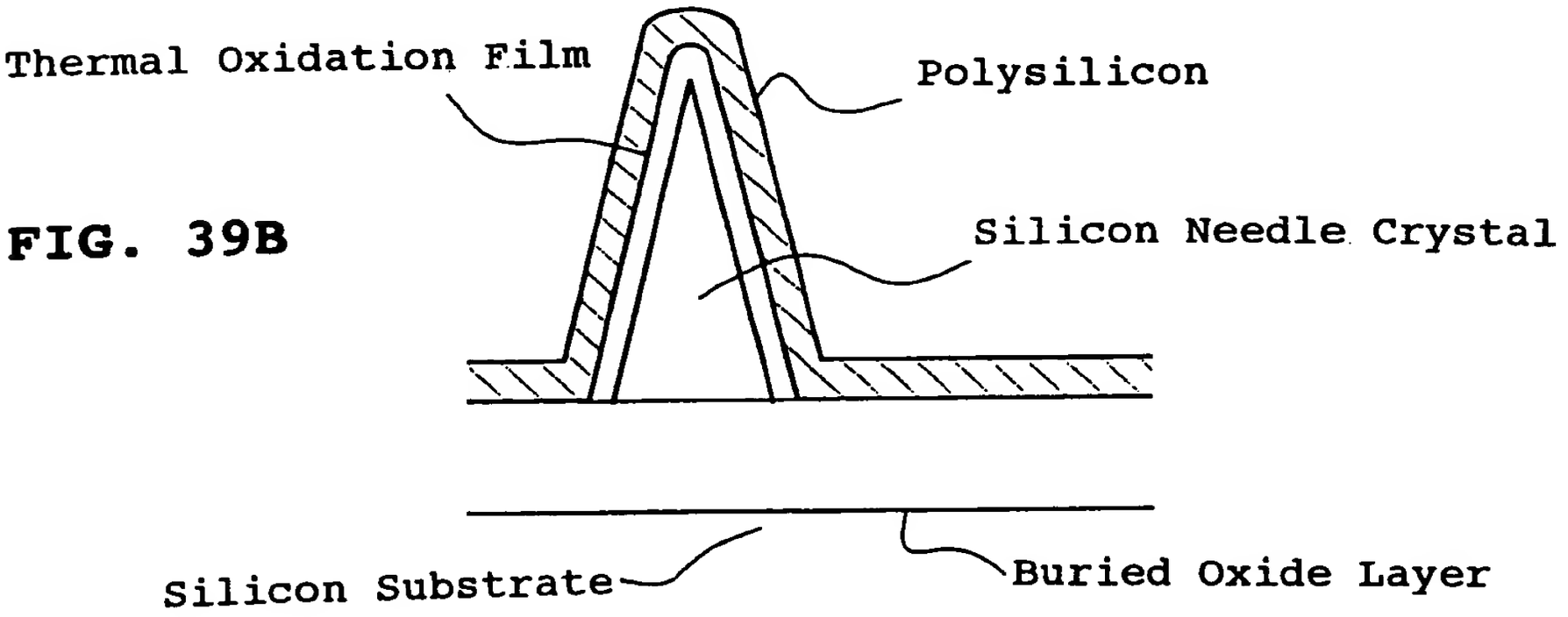


FIG. 39B

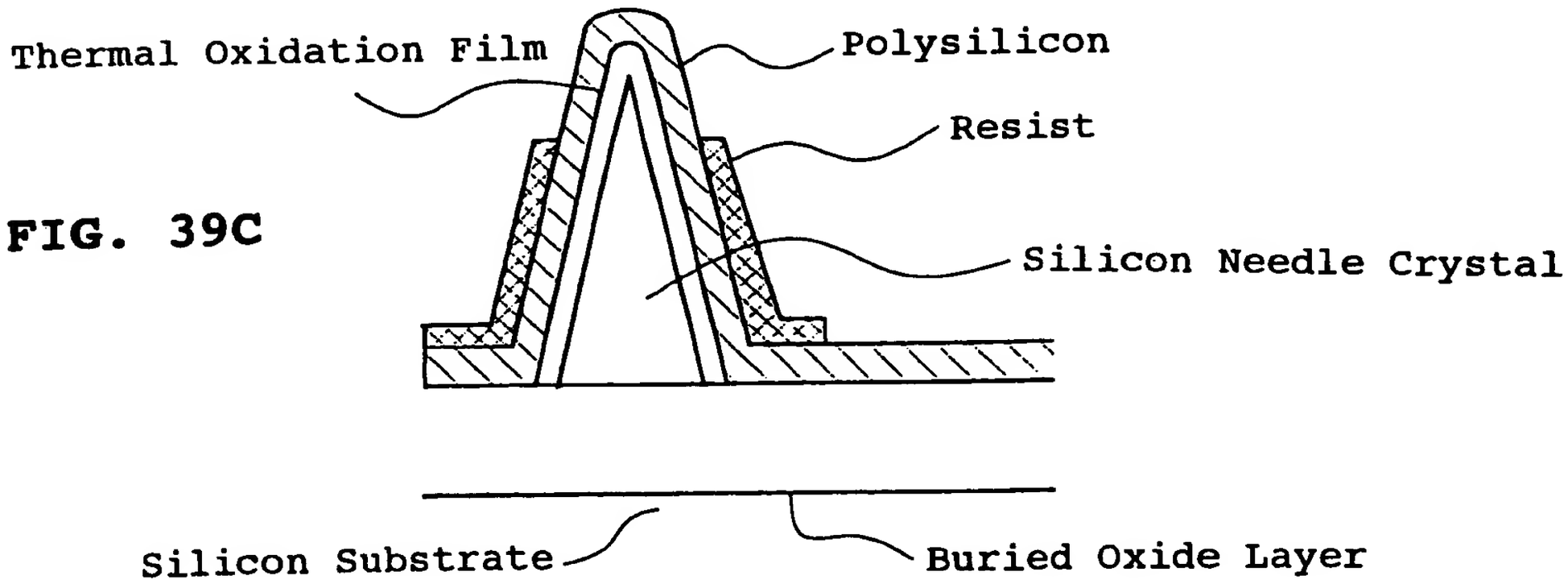


FIG. 39C

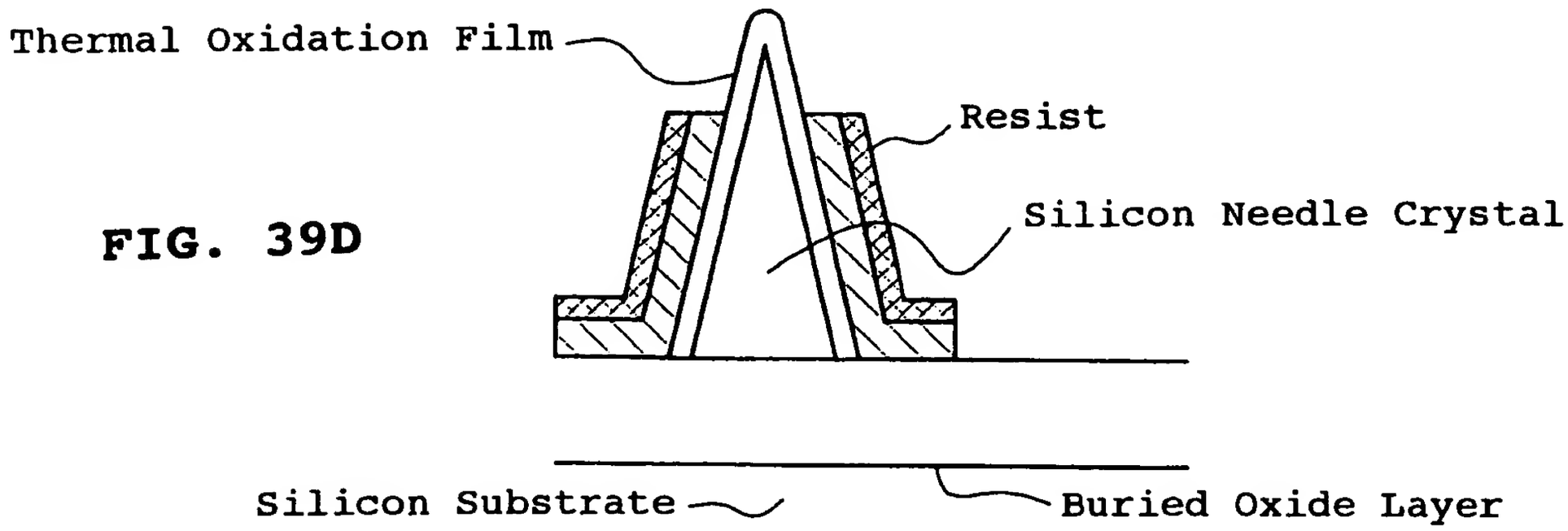


FIG. 39D

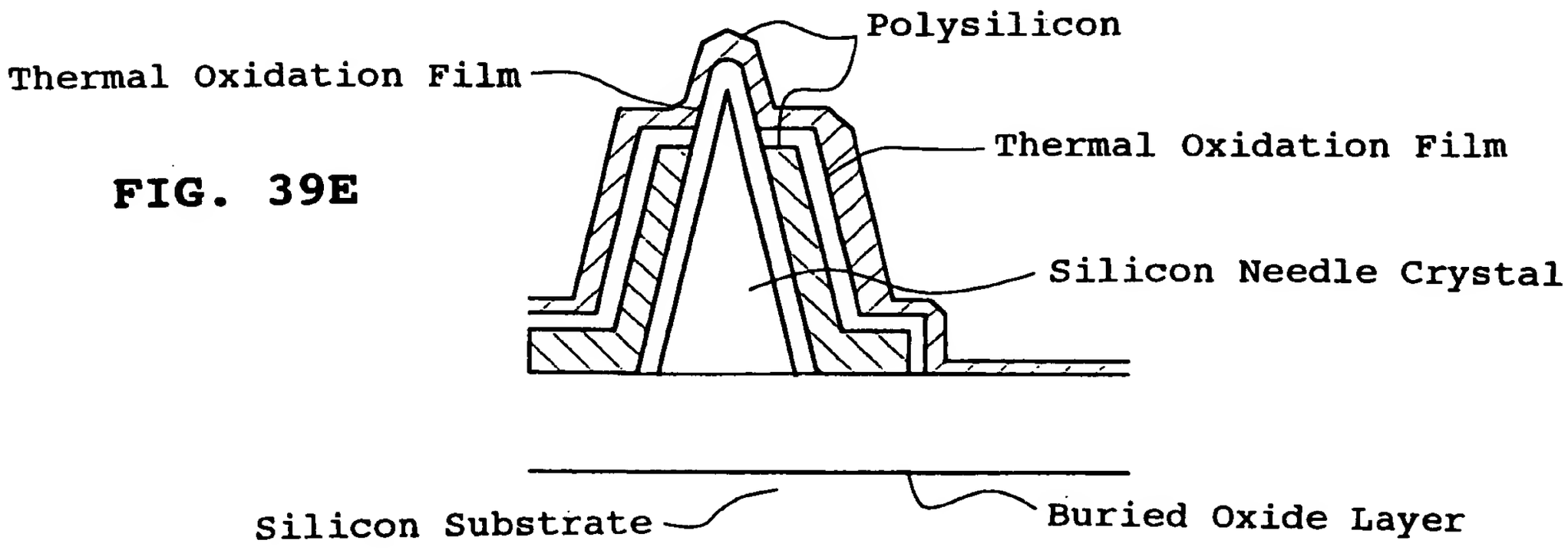


FIG. 39E

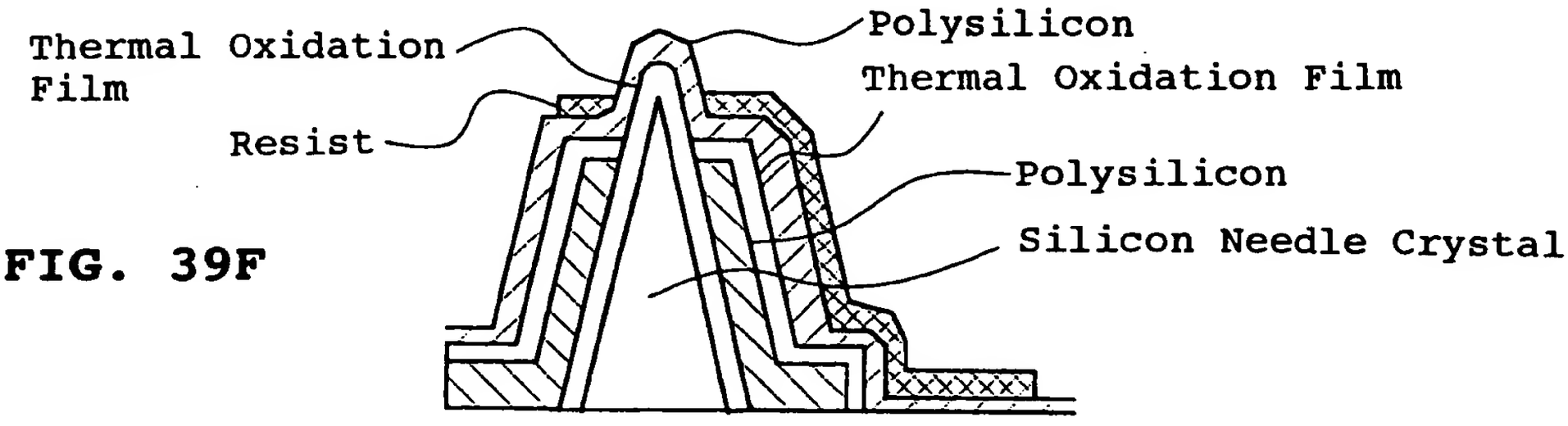


FIG. 39F

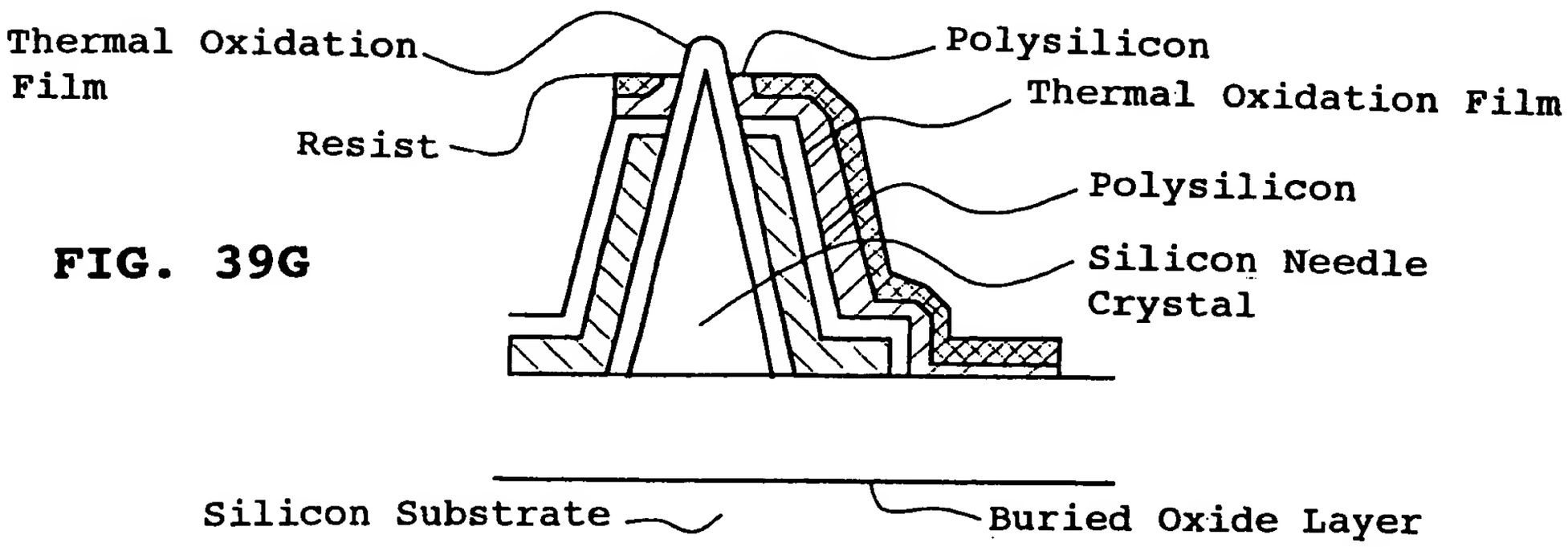


FIG. 39G

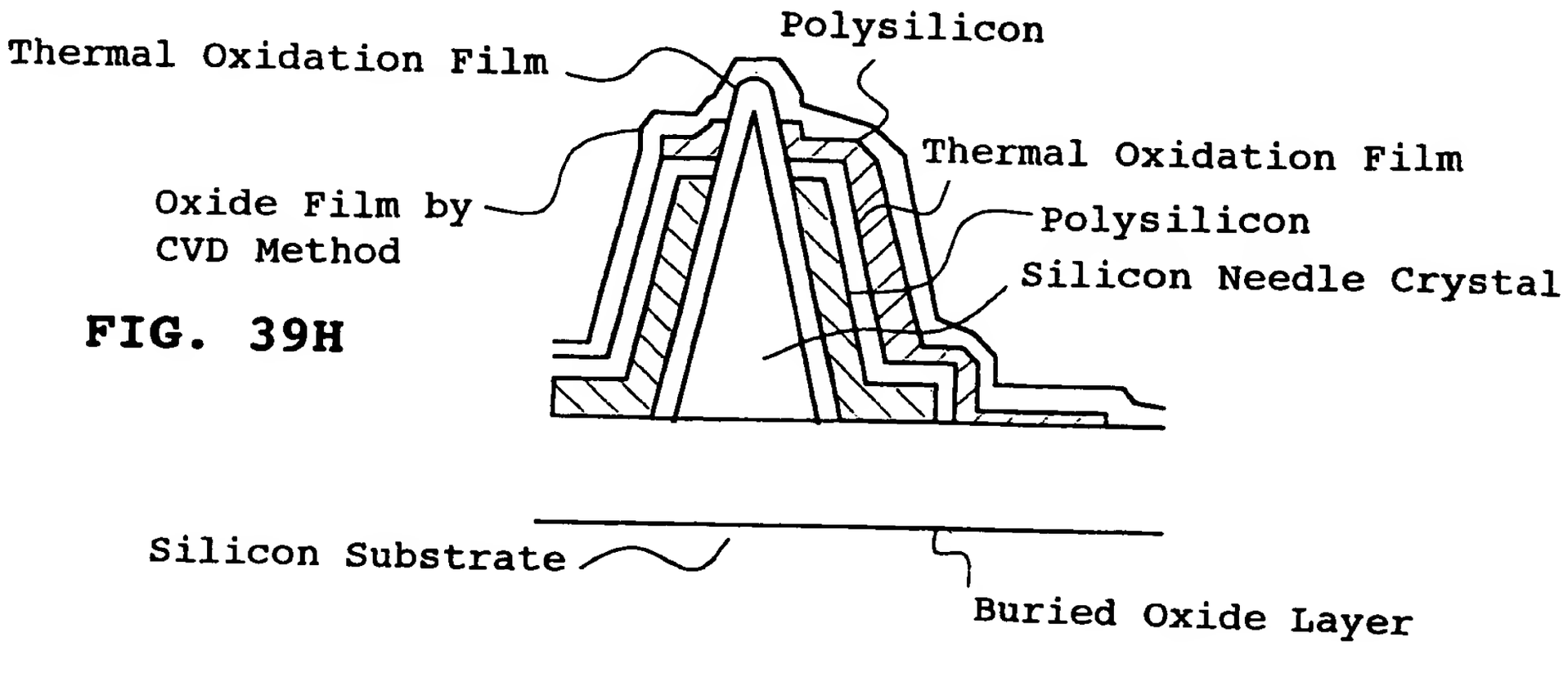


FIG. 39H

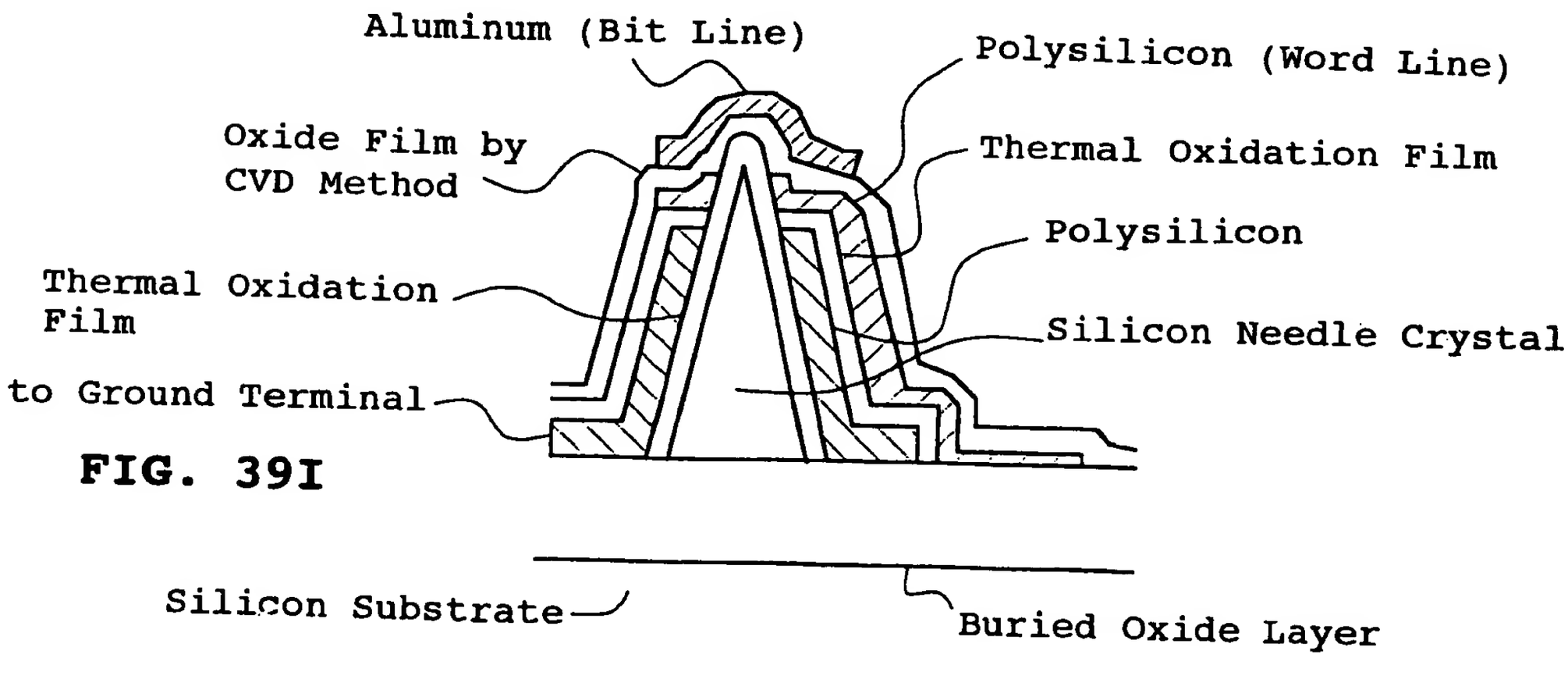


FIG. 39I